MAY 14 1925

ENGINEERING:

An Illustrated Weekly Journal.

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AUTOMATIC FEED REGULATORS.
And Auxiliary Machinery as supplied to the Admiralty. 3170

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Sole Licensees in Great Britain for the manufacture of "Armco" Rust and Corrosion Resisting Iron Tubes. 2257
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See Advertisement, page 33, April 24.

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Worm Wheels cut up to 13 ft. diam.
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Naval Outfits a Speciality, also for Merchant Ships, for Factories, Locomotives, and Industrial Process Furnaces of all kinds.
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STEWARTS AND LLOYDS, Ltd.
GLASGOW BIRMINGHAM LONDON.
See Advertisement, page 81. 2584

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PETERBOROUGH.
STEAM ENGINES AND TURBINES.
GAS AND OIL ENGINES,
AIR COMPRESSORS.
REFRIGERATING PLANT. 1375
See Advertisement, page 53, April 24.

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Half price. Send for list.
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300/325 I.H.P. Corliss
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Belt flywheels 16 ft. diameter by 30 in. wide. Corliss valves to inlet and exhaust of both cylinders. Vertical Air Pump and Condenser below floor level, worked by L.P. crosshead.
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Two LANCASHIRE BOILERS, by Horsfields, 30 ft. by 8 ft. dia., loaned for 200 lbs. pressure; with Green's type Economiser, 120 pipes, and Motor and Steam Driven Boiler Feed Pumps.
Two 175 Kw. Brownett-Bruce Peebles GENERATING SETS, 230/250 volts, 420 r.p.m., switchboards; with Surface Condensers, motor-driven air and circulating pumps. Would separate plant if required.
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Telegrams: "Eps," London.
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SYPHONIA STEAM TRAPS, REDUCING VALVES
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YARROW BOILERS.
2677

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Walter Somers, Limited,
HALESOWEN 7116
Matthew Paul & Co., Ltd.,
LIVERPOOL WORKS Dumbarton. 2643
See Full Page Advt., page 65, April 24.

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For Production of SHEET METAL WORK, COINAGE, CARTRIDGES AND GUNPOWDER.
Foundry, Works and Showrooms: BIRMINGHAM.
See Advert., page 62 April 24. 3100

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The Manchester Steam Users ASSOCIATION.

For the prevention of Steam Boiler Explosions and for the attainment of Economy in the Application of Steam. 9, MOUNT STREET, MANCHESTER.

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Draughtsmen, before

Negotiating with Government Departments in connection with any post, please communicate with the GENERAL SECRETARY, Association of Engineering and Shipbuilding Draughtsmen, 95, St. George's Square, London, S.W.1. G 758

TENDERS.

WIGAN UNION.

The Guardians of the Poor of the Wigan Union invite

Tenders for the Supply,

DELIVERY and ERECTION of ONE ELECTRICAL VERTICAL PUMPING PLANT, Heating and Domestic Hot-water Supply Apparatus, Alterations of Buildings, Additions, and making a Well at the Poor Law Infirmary, Billinge, near Wigan.

Copies of the specification and general conditions may be obtained from me, the undersigned, on payment of a fee of £3 3s., which will be returned upon receipt of a bona-fide Tender, and plans can be inspected at this Office at any time during Office Hours.

Tenders, to be sealed and endorsed "Tender for Plant, Billinge Infirmary," to be delivered to me not later than four p.m., on Monday, the 26th May, 1925.

The Guardians do not bind themselves to accept the lowest or any Tender.

By Order of the Board,
H. GORDON ACKERLEY,
Victoria Buildings, Clerk.
King Street, Wigan.
20th April, 1925. H 822

PORT OF BRISTOL.

RECONSTRUCTION OF SHED "V," BRISTOL.

The Docks Committee invite

Tenders for the Reconstruction,

mainly in Ferro-concrete, of the DOUBLE FLOOR TRANSIT SHED, known as Shed "V," situate on Canon's Road, Bristol.

On and after Friday, the 1st May, 1925, a copy of the Form of Tender, General Conditions, Specification, Schedule of Prices, and a copy of the Contract Drawings can be obtained from the undersigned on production of a receipt showing that a deposit of £5 has been paid to the General Manager and Secretary of the Bristol Docks Committee TO WHOM ALL CHEQUES MUST BE MADE PAYABLE. The deposit of £5 will be returned hereafter to all *bona fide* Tenderers.

Tenders must be enclosed in a sealed envelope endorsed, "Tender for the Reconstruction of Shed 'V,' Bristol," addressed to the General Manager and Secretary of the Docks Committee, 19, Queen Square, Bristol, and must be delivered to him, accompanied by all the prescribed documents and drawings, before Ten a.m., on Monday, the 1st day of June, 1925.

The Docks Committee do not bind themselves to accept the lowest or any Tender.

THOMAS A. PEACH,
Chief Engineer,
Port of Bristol.

Chief Engineer's Office,
Avonmouth Docks,
24th April, 1925. H 841

CITY OF LEICESTER.

STORM WATER AND SEWAGE DISPOSAL WORKS.

CONTRACT NO. 4.

CAST-IRON PIPES AND OTHER IRONWORK.

The Leicester Corporation are prepared to receive

Tenders for the Supply and

DELIVERY of CAST-IRON PIPES, BENDS, BRANCHES, SPECIAL CASTINGS and SLUICE VALVES for rising mains, and for other IRONWORK in connection with Sewage Disposal Works.

The Contract is divided into the following sections:—

Section A. Cast-iron pipes.
Section B. Cast-iron pipe specials.
Section C. Sluice valves, wall penstocks, floating arms, etc.
Section D. Automatic revolving sewage distributors.

Tenders may be submitted for any or all of the items.

Copies of the Conditions of Contract, Specification, Bill of Quantities, with Form of Tender, etc., may be obtained at my Office on and after 30th April, 1925, on payment of the sum of £2, which will be returned on receipt of a *bona fide* Tender.

Cheques, etc., to be crossed and made payable to the Leicester Corporation.

Sealed Tenders, together with the Summary of Tender on the Forms supplied, filled up and addressed to "The Chairman of the Sewage Works and Farms Committee, Town Hall, Leicester," are to be delivered not later than Nine a.m., on 9th May, 1925, endorsed "Tender for Cast-iron Pipes and other Ironwork."

The Corporation do not bind themselves to accept the lowest or any Tender.

R. GEORGE MAWBEY, M.Inst.C.E.
City Engineer and Surveyor.

Town Hall, Leicester,
April, 1925. H 869

THE PUBLIC WORKS DEPARTMENT OF THE EGYPTIAN GOVERNMENT is calling for

Tenders for:

SUPPLYING, LAYING, JOINTING, and TESTING of about 11,600 lin. metres of 46-in. diam. O.I. PIPING (Brit. Standard), between Kafr el Gamous Drainage Pumping Station and Gebel el Asfar Farm. Tenderers must have had previous experience in this work.

Tender forms, conditions, drawings, etc., to be obtained from:—

THE INSPECTING ENGINEER,
Egyptian Government,
Queen Anne's Chambers,
Westminster, S.W.1.

Price £5 2s. 6d. (not returnable).
Please quote Reference No. Main Drainage 6437.
Tenders due on June 15th, in Cairo. H 886

For Disposal by Tender,

40,000 tons (ex-German) FLOATING DOCK, No. 23.

THE ADMIRALTY have for disposal, without restriction as to use abroad, the above-mentioned Dock, lying in sections at Chatham.

Brief particulars of the Dock are as follows:—

Lifting Capacity.....40,000 tons.
Length overall .....702 ft. 9 ins.
Breadth .....194 ft.
Breadth to outside walls.....183 ft. 10 ins.
Width inside at top of walls .....154 ft. 2 ins.
Width inside at bottom of walls...147 ft. 10 ins.
Minimum inside width (between fenders) .....147 ft. 2 ins.
Length of M.L. Keel Blocks.....700 ft.
Height of Blocks .....4 ft. 3 ins.
Maximum draught of ship dockable, about .....36 ft.
Depth of water required at sills to dock ship of 36 ft. draught..... 63 ft. 6 ins.
Time for lifting large ship... ..... 2—3 hours.

The sections of the Dock are for sale as and where they lie, and without any guarantees. Further particulars, Tender Forms, Conditions of Sale, etc., together with an order to view, may be obtained upon application to the DIRECTOR OF NAVY CONTRACTS, ADMIRALTY, Room 62, Princes House, Kingsway, London, W.C.2.

Sealed Tenders are due at the Admiralty by Noon, on Tuesday the 12th May, 1925. H 758

METROPOLITAN ASYLUMS BOARD.

TO HEATING ENGINEERS.

The Board invite

Tenders for Removing Existing

Heating Apparatus, and Providing and FIXING NEW STEAM HEATING CALORIFIERS, STEAM and CONDENSE PIPING, etc., at the North-Western Fever Hospital, Lawn Road, Hampstead, N.W.3, in accordance with the Specification and Drawings prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawings, and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., on Wednesday, 29th April, 1925, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawings have been returned.

Tenders, addressed as noted on the Form, must be delivered at the Office of the Board not later than Ten a.m., on Thursday, 14th May, 1925.

G. A. POWELL,
Clerk to the Board. H 836

LIFFEY TUNNEL.

THE DUBLIN PORT AND DOCKS BOARD invite

Tenders from Responsible and

Experienced Contractors for the CONSTRUCTION of a SUBWAY under the River Liffey, at Dublin.

Applicants must submit with their Tender a statement of their previous experience of subaqueous tunnelling, together with a list of the works carried out by them and the contract price of same. No Tenders will be entertained from firms which have not had experience as principal contractor on such works.

The works to be carried out will comprise the following:—

The construction of—

(a) Two 18 ft. 0 in. internal diameter Shafts, about 70 ft. deep.
(b) One 11 ft. 9 in. internal diameter Iron-lined Tunnel, about 880 feet in length.
(c) Two Shaft Houses with all fittings.
(d) Two Electric Lifts and Two Stairways.
(e) Ventilation and Lighting System in Tunnel and Shafts, and all other fittings shown or specified.
(f) All Temporary Works, Compressed-Air Plant, etc., necessary for the execution of the contract.

Specification, Drawings and Form of Tender may be obtained on application at the Engineer's Office, Dublin Port and Docks Board, East Wall, Dublin, on and after the 15th April, 1925, between the hours of Ten a.m., and Four p.m. Such applications must be accompanied by a receipt from The Secretary to the Board for a deposit of £10, which must be lodged with the Secretary, Dublin Port and Docks Board, Westmoreland Street, Dublin. This deposit will be refunded on receipt of a *bona fide* Tender, accompanied by all drawings and documents obtained from the Engineer.

Tenderers desiring to have extra copies of any of the drawings to assist them in preparing their Tender will be supplied with such copies on payment of a sum of 5s. per sheet, which sum will not be returned. All drawings so supplied must be returned under separate cover at the same time as the Tender is submitted.

Tenders must be delivered under seal, addressed to THE SECRETARY, Dublin Port and Docks Board, Westmoreland Street, Dublin, and endorsed "Tender for Liffey Tunnel," not later than Eleven a.m., on Tuesday the 12th May, 1925. No Tender will be entertained unless so delivered.

The Board do not bind themselves to accept the lowest or any Tender.

Port and Docks Office,
8th April, 1925. H 751

THE DIRECTOR-GENERAL, INDIA STORE DEPARTMENT, Branch No. 16, Belvedere Road, Lambeth, S.E.1, invites

Tenders for:—

1. COMPLETE BOILER INSTALLATION for Electric Power House, consisting of Cornish Boilers, Underfeed Stokers, Economiser, Chimney, Piping, etc.
2. WHEELS and AXLES.

Tenders due on the 19th May, 1925, for No. 1 and on the 15th May, 1925, for No. 2.

Tender Forms obtainable from above. H 879

HEATING.

THE COMMISSIONERS OF HIS MAJESTY'S WORKS, Etc., are prepared to receive

Tenders before Eleven

a.m. on Friday, 15th May, 1925, for RE-ARRANGEMENT of HEATING APPARATUS at the British Museum.

Drawings, Specification, a copy of the Conditions and Form of Contract, Bills of Quantities, Forms for Tender, etc., may be obtained from the CONTRACTS BRANCH, H.M. OFFICE OF WORKS, King Charles Street, London, S.W.1, on payment of One Guinea. (Cheques payable to The Commissioners of H.M. Works, &c.) The sums so paid will be returned to those persons who send in Tenders in conformity with the conditions. H 896

METROPOLITAN ASYLUMS BOARD.

TO LAUNDRY ENGINEERS AND OTHERS.

The Board invite separate

Tenders for the Installation of

SIX-ROLLER IRONING MACHINE at COLINDALE HOSPITAL, HENDON, N.W.9, in accordance with the Specification and Drawing prepared by Mr. T. COOPER, M.Inst.C.E., M.I.Mech.E., Engineer-in-Chief. The Specification, Drawing and Form of Tender may be inspected at the Office of the Board, Victoria Embankment, E.C.4, on and after Ten a.m., Wednesday, 29th April, 1925, and can then be obtained upon payment of a deposit of £1. The amount of the deposit will be returned only after the receipt of a *bona fide* Tender sent in accordance with the instructions on the Form of Tender and after the Specification and the Drawing have been returned.

Tenders, addressed as noted on Form, must be delivered at the Office of the Board not later than Ten a.m., on Thursday, 14th May, 1925.

G. A. POWELL,
Clerk to the Board. H 926

URBAN DISTRICT COUNCIL OF ASHBORNE.

EDLASTON WATER SCHEME—CONTRACT No. 1.

TENDERS FOR BOREHOLE.

The Council invite

Tenders for the Sinking and

TESTING of a BOREHOLE at Edlaston, near Ashborne, Derbyshire. The Borehole will be 24-inch diameter reducing to 18-inch diameter, and is to be sunk by a Rotary process to secure solid cores. The Contract includes a second and similar borehole to be sunk only if the first proves satisfactory on test.

The General Conditions, Specification, Schedule and Form of Tender, prepared by Dr. H. LAPWORTH, M.Inst.C.E., Westminster, may be obtained from the UNDERSIGNED, on and after Monday, May 4th, on payment of £2, which will be returned on receipt of a *bona-fide* Tender.

Sealed Tenders, endorsed "Tender for Edlaston Boring," to be sent to the UNDERSIGNED not later than Monday, May 18th.

The Council do not bind themselves to accept the lowest or any Tender.

D. POWELL,
Surveyor to the Council.

Council Offices,
Ashborne, Derbyshire. H 915

THE SOUTH INDIAN RAILWAY COMPANY, LIMITED.

The Directors are prepared to receive

Tenders for the Supply

of:—

1. POINTS AND CROSSINGS, etc.
2. ELECTRIC OVERHEAD TRAVELLING CRANE.

Specifications and Forms of Tender will be available at the Company's Offices, 91, Petty France, Westminster, S.W.1.

Tenders, addressed to the Chairman and Directors of the South Indian Railway Company, Limited, marked, "Tender for Points and Crossings," or as the case may be, must be left with the undersigned not later than Twelve Noon, on Friday, the 22nd May, 1925.

The Directors do not bind themselves to accept the lowest or any Tender.

A charge, which will not be returned, will be made of 10s. for each copy of Specification No. 1, and of 5s. for each copy of specification No. 2.

Copies of the Drawings may be obtained at the Offices of the Company's Consulting Engineers, Messrs. ROBERT WHITE & PARTNERS, of 8, Victoria Street, Westminster, S.W.1.

A. MUIRHEAD,
Managing Director.

91, Petty France, S.W.1.
20th April, 1925. H 936

APPOINTMENTS OPEN.

THE UNIVERSITY OF SHEFFIELD.

ASSISTANT LECTURESHIP IN CIVIL ENGINEERING.

The Council are about to

Appoint an Assistant Lecturer

in CIVIL ENGINEERING. Salary £300 per annum. Further particulars may be obtained from the undersigned, with whom applications should be lodged by the 22nd May.

W. M. GIBBONS, Registrar.
H 902

DEPARTMENT OF SCIENTIFIC AND INDUSTRIAL RESEARCH.

One or Two JUNIOR

ASSISTANTS are REQUIRED at the NATIONAL PHYSICAL LABORATORY. Candidates must have a good Honours Degree or equivalent qualification in Physics, Engineering or Electrical Engineering, preferably with some experience in research.

Scale of salary £175—15—£235 per annum plus Civil Service Bonus: present initial pay £270 10s. Superannuation provision will be made under the Federated Superannuation System for Universities, by a contribution of approximately 10 per cent. of salary from the Department and 5 per cent. from the officer.

Preference will be given, other things being equal, to ex-service men.—Application must be made on a form to be obtained from the Laboratory, and must be received by the DIRECTOR, National Physical Laboratory, Teddington, not later than May 9th. H 923

Wanted Assistant to Works

Manager for heavy structural engineering works, near Glasgow. Must be a capable and practical man, able to control labour, a good organiser, and have experience of methods of production in an up-to-date shop.—Address, stating age, experience and salary expected, to the SECRETARY, MOTHERWELL BRIDGE AND ENGINEERING CO., LTD., Motherwell. H 910

COVENTRY EDUCATION COMMITTEE.

MUNICIPAL TECHNICAL INSTITUTE.

Workshop Instructor Re-

QUIRED in Mechanical Engineering Department. Candidates must be capable of lecturing on, and giving instruction in, up-to-date machine shop practice. Salary, £350 per annum.

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FRANK H. HARROD,
Director of Education.

Council House,
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WORKS Company (in England) a SUPERINTENDING INSPECTOR—permanent employment—about 35 years of age. Must be of active habits, good address and health, thoroughly acquainted with modern plumbing work, water fittings and installations in large business and trade establishments, as well as in private houses, and capable of advising consumers thereon. A thorough knowledge of waste detection in mains, domestic service pipes and fittings is essential. Applicants must also have a thorough mechanical knowledge of meters and be capable of supervising repairs thereto. The applicant appointed will also be required to supervise all meter readings (2000 meters) and keep the meter books from which accounts are made out. He will also be responsible for the Company's staff of Waste Inspectors (now nine in number, meter readers, repairers, etc., and he will be required to reside on the Company's premises and take duty outside office hours alternately with the Company's Mains Superintendent, and deal with complaints and breakdowns arising at such times. Salary £300, rising by yearly increments of £20 to £400, with house, rent and rates free, less 5 per cent. annual contribution to the Company's Superannuation Fund, the joining of which is compulsory. Applications will only be considered from those with good experience in similar work, and these must be received not later than May 23rd next and must be made on forms obtainable after May 2nd on application.—Address, H 901, Offices of ENGINEERING.

SUNDERLAND EDUCATION COMMITTEE.

THE TECHNICAL COLLEGE.
Department of Mechanical Engineering.

The Committee invite

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of HEAD of the MECHANICAL ENGINEERING DEPARTMENT. Applicants must possess an Honours Degree and have had good drawing office and works experience.

The standard of the full-time day courses is that required for an honours University degree, and that of the part-time evening courses (T. 4 to T. 8) is suitable for Senior and Advanced students from the marine engineering drawing offices and works of the district. Experience in all types of prime movers, steam and oil, is desirable. There are courses also in advanced Structures, Hydraulics, etc.

Present Salary Scale £600-£30-£600, less five per cent. voluntary abatement. This Scale is subject to reconsideration in view of the Burnham Award, 1925.

Application forms can be obtained from the undersigned, and should be returned not later than Monday, 18th May, 1925.

HERBERT REED,
Chief Education Officer.

Education Offices,
15, John Street,
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22nd April, 1925. H 885

Civil Engineer, Electrical

and Mechanical, REQUIRED for duty in Air Ministry Works and Buildings Department, Iraq. Candidates must be ex-Service, should be not more than 35 years of age and preferably unmarried.

They should have served apprenticeship in large engineering works, had experience in construction, operation and maintenance of electrical generating plant, both A.C. and D.C., steam and internal combustion engines, pumping plant and general engineering works, with overseas experience. Must be Corporate Members of either Institution of Mechanical Engineers or Institution of Electrical Engineers. Salary £400-£500 according to experience, plus Civil bonus (a total salary equivalent at present rate of bonus to from £588 to £690), and Foreign Service Allowance of Rs. 475 a month (Married rate); Rs. 270 a month (Single rate).—Applications should be addressed to SECRETARY, Air Ministry (W.B.5), Kingsway, W.C.2. H 907

AN INTERNATIONAL COMPARISON OF ENGINEERING WAGES.

PRIOR to the war the fluctuation of wages in the British engineering industry followed the fluctuations in the prosperity of the industry as determined principally by unemployment statistics. During the war this criterion was superseded by the cost of living index figure, owing to the necessity for adjusting the discrepancy between the real and nominal value of wages during the period of violent price fluctuations. For the last two years the cost-of-living figure has remained comparatively stable, apart from regular seasonal fluctuations, while the unemployment percentage has ceased to be a reliable criterion owing to the extensive artificial measures undertaken by the Government, the municipalities, and individual concerns, for the purpose of giving employment which would not be available under the free play of economic forces.

In these circumstances, it is not remarkable that the need is being felt for some new guide for the adjustment of engineering wages in what may now be safely termed the "new normal" post-war conditions. Public interest has been drawn to this question intermittently by the protracted negotiations between the two parties in the industry, which have now been in progress for nearly a year, and are not yet terminated. Latterly, it has given rise to a great deal of discussion in the press and in Parliament, especial prominence being given to the contrast between the wages paid in sheltered and unsheltered industries on the one hand, and to the inadequacy of engineering wage rates compared with pre-war rates when measured by the cost-of-living index on the other.

With regard to the latter point, it may be well to emphasise that in an industry such as engineering, with its extensive application of payment by results and its generous working conditions, a comparison of wage rates with the cost-of-living index is misleading. The total earnings of the workpeople, the sum which the workman takes home at the end of the week, is the sum out of which he has to defray his expenses, and it need hardly be said that this sum greatly exceeds the bare-wage rates. An investigation from an extensive sample of representative engineering firms recently made on this basis shows that these average earnings have risen in approximately equal ratio to the cost of living since 1914—in other words the standard of living of the British engineer, as gauged by real monetary earnings, has not fallen absolutely since 1914, in spite of the reduction of the working week from 53½ to 47 hours. This is a matter for no small satisfaction, having regard to the necessity of discharging interest on war debt each year out of a smaller volume of production than in 1913—a necessity which can only result in the reduction of the standard of living of the nation as a whole.

Relatively to those engaged in other industries the status of engineers has, however, undergone a material change. Broadly speaking, the sheltered trades have improved their position relatively to engineering to such an extent that the latter industry is losing its former attractiveness to the best type of recruit. This dangerous tendency could be arrested either by lowering the wages of sheltered industries or raising those of the engineering industry. Of these alternatives, the first presents very great difficulty owing to the power of organised labour in the sheltered trades to suspend essential public services. A readjustment on these lines to the pre-war relation could, therefore only follow a re-orientation of public opinion. In any case, the assessment of the relative value of the respective contributions to national productivity of, say, a railway porter and a skilled engineer, is a complicated question involving many arbitrary assumptions.

The second alternative—that of increasing engineering wages—which may seem easy enough to a superficial view, would be of doubtful expediency. It is certainly a delusion to suppose that an increase in nominal wages would necessarily mean an increase in real wages. On the contrary, if the increase were on an uneconomic basis, it would merely raise the cost of living. This would not benefit the people in receipt of wages, while the resulting increase in the cost of production and consequently selling prices, would reduce the competitive power of the industry and thereby employment. Again, an increase of wages in a depressed industry such as engineering would be the signal for further increases in sheltered industries, which, on the face of it, would leave the position as it was before.

There is perhaps a danger to-day that in the contemplation of these rival difficulties in the realm of expediency, the merits of the case are being lost sight of. If so, it will be useful to draw attention to the underlying economic factors which cannot ultimately be ignored. In one of the valuable series of pronouncements made by Mr. W. L. Hichens recently, the following passage occurs :—

"I do not see how in the long run we could pay higher wages than other countries unless we have some natural advantage such as cheaper coal, or cheaper iron ore, or superior mechanical devices, or a protective tariff which would cover a big home market such as they have in the United States. We have not got, comparatively speaking, a big home market; therefore a protective tariff would probably do us no good. Nor would it be said that we have greater natural resources, better machinery, superior organisation, or a more industrious population than our rivals. In the long run it seems to me that the wages and hours of work must tend towards equality in the various manufacturing countries."

Of the soundness of these conclusions there can really be no question. If, then, engineering wages and hours in this country were, competitively speaking, less advantageous than or even equal to those abroad, any sound and enduring solution of the "relativity" problem must come otherwise than by increasing engineering wages. In that event it becomes of the first importance that public attention should be directed to the facts of the case, and a comparison of international wages assumes more than an academic interest.

For the purposes of such an international comparison wages may conveniently be considered in two main aspects—their competitive value and their purchasing value. The competitive value of wages may be defined as the comparative cost of labour per hour worked in one country in relation to that in another. This, of course, is the aspect which primarily affects the employer. The purchasing value of wages is their value to the workmen in enabling him to purchase the necessaries of existence. But each of these aspects of wages reacts upon the other, since the fluctuation of wages in an unsheltered industry in any country are bounded on one side by the ability of the industry to pay, having regard to competitive conditions, and on the other by the minimum standard of living acceptable to the workpeople which cannot, in any event, be lower than the level necessary for subsistence. For a proper international comparison it is, therefore, necessary to ascertain both the competitive and the purchasing values of wages in the various countries covered by the investigation.

For both of these purposes the total earnings of workpeople as opposed to rates of wages would be desirable for an accurate comparison, since in the case of purchasing value it is the total earnings which decide the purchasing power of the workmen and in the case of competitive value it is the sum of the total earnings of all the workpeople which makes up the labour cost of production. Unfortunately earnings figures are not at present compiled in many of the principal engineering countries. It is therefore necessary to make use of wage rates for the purpose in view. If the ratio of wage rates to earnings was identical in the various countries, this would be a matter of small importance, but from such data as is available there appears to be some variation. In view of this factor, accuracy within narrow limits cannot be claimed for the conclusions but the error is certainly not great enough seriously to impair their validity.

Comparison of the Purchase Power of Engineering Wages.—The value of a comparison of the purchasing power of engineering wages is subject to certain limitations. Firstly, in order to make the comparison at all, it is necessary to take some common denominator—in this case the price of commodities which make up the normal budget of the British workman and to assess the purchasing power of wages in different countries in relation to that cost in those countries. Actually, of course, the component elements of the budgets of the workpeople in different countries vary considerably. Again, an incalculable element is introduced in the variation in the ability of housewives in different countries to make use of a given amount of purchasing power. Finally, the comparability within narrow limits of the index figures of the cost of living in the various countries is itself open to question. For practical purposes these technical difficulties may be disregarded as in the Board of Trade investigation on this subject undertaken in 1905. From the results of that investigation the purchasing power of wages in the five countries investigated before the war was as follows :—

TABLE I.—*Comparative Purchasing Power of Engineering Wages before the War.*

(Ratio Great Britain = 100.)

—	Nominal Hourly Rate.		Internal Purchasing Power.	Purchasing Power of Wages.	
	Skilled.	Unskilled.		Skilled.	Unskilled.
U.S.A.	200	191	152	131·5	125·6
Germany ..	75	89	119	63·0	74·8
France	69	76	114	60·5	66·6
Great Britain ..	100	100	100	100·0	100·0
Belgium ..	52	60	94	55·3	63·8

At the present time the wide discrepancies between the internal and external purchasing power of the various currencies and the impossibility of assessing them makes it necessary to go back to this pre-war ratio and re-calculate the purchasing power of present wages from that basis. The method is best explained by the following example :

The present hourly wage rate of a skilled engineer in France is 3·45 francs. The cost of living index figure in France (1914 = 100) is 377. Consequently, the equivalent of the present wage in 1914 would have been $\frac{3{\cdot}45 \times 100}{377}$, or 0·91 francs. Converted into English money at the pre-war rate of exchange (25·321 francs to the £), this becomes 8·7*d.* But since, as we have seen in Table I that the cost of living in pre-war France was 14 per cent. higher than in pre-war Great Britain, the equivalent of 8·7*d.* in France at that time would have been 7·6*d.* in Britain. Now the cost of living index figure in this country in December, 1924, was 180 (1914 = 100). Therefore, the sum giving equal purchasing power ir Great Britain in December, 1924, to that of 7·6*d.* in 1914 = $\frac{7{\cdot}6 \times 180}{100}$, or 13·7*d.* The present rate of a skilled engineer in Great Britain is 14·5*d.* The ratio of the real wages of a British engineer to that of a French engineer is, therefore, as 14·5*d.* is to 13·7*d.*, or as 100 to 94·5. Applying this method to the other countries for which data are available, the following result is obtained :—

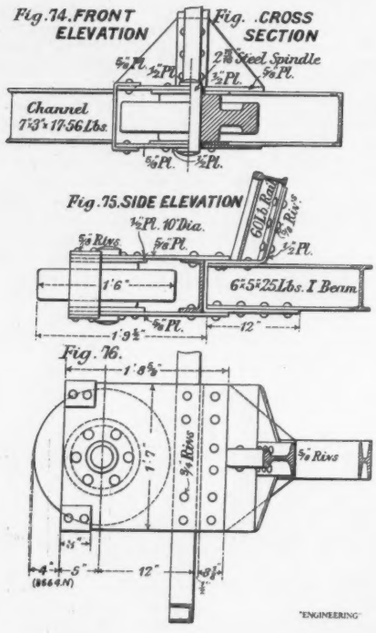
TABLE II.—*Comparative Purchasing Power of Engineering Wages in December*, 1924.

—	Skilled.	Unskilled.
U.S.A...	219·6	217·5
Great Britain..	100·0	100·0
France..	94·5	91·7
Belgium	72·4	78·0
Germany	73·1	72·2

From a comparison of Tables I and II it will be seen that while the United States has enormously improved its position relatively to this country since before the war, an improvement has also taken place in the relationship of the other countries for which a comparison is made. In the case of France, the standard of living of her engineering workpeople has nearly reached our own. Belgium and Germany have also made an improvement, but are still approximately 25 per cent. below the British level. The willingness or ability of the workpeople of these important competitive countries to put up with this state of affairs is in itself a vital point.

(*To be continued.*)

THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY WEIR.



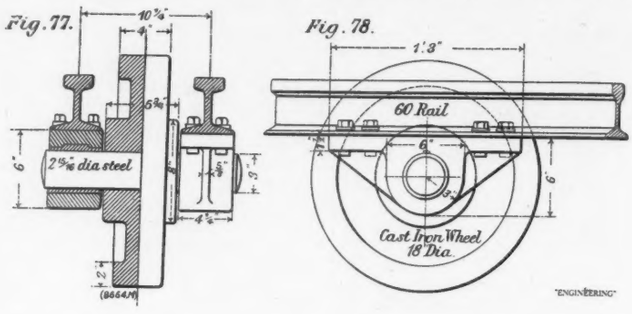


FIG. 79. NEW CHANNEL IN FLOOD.

THE REGULATION OF THE MURRAY RIVER.

(*Continued from page* 470.)

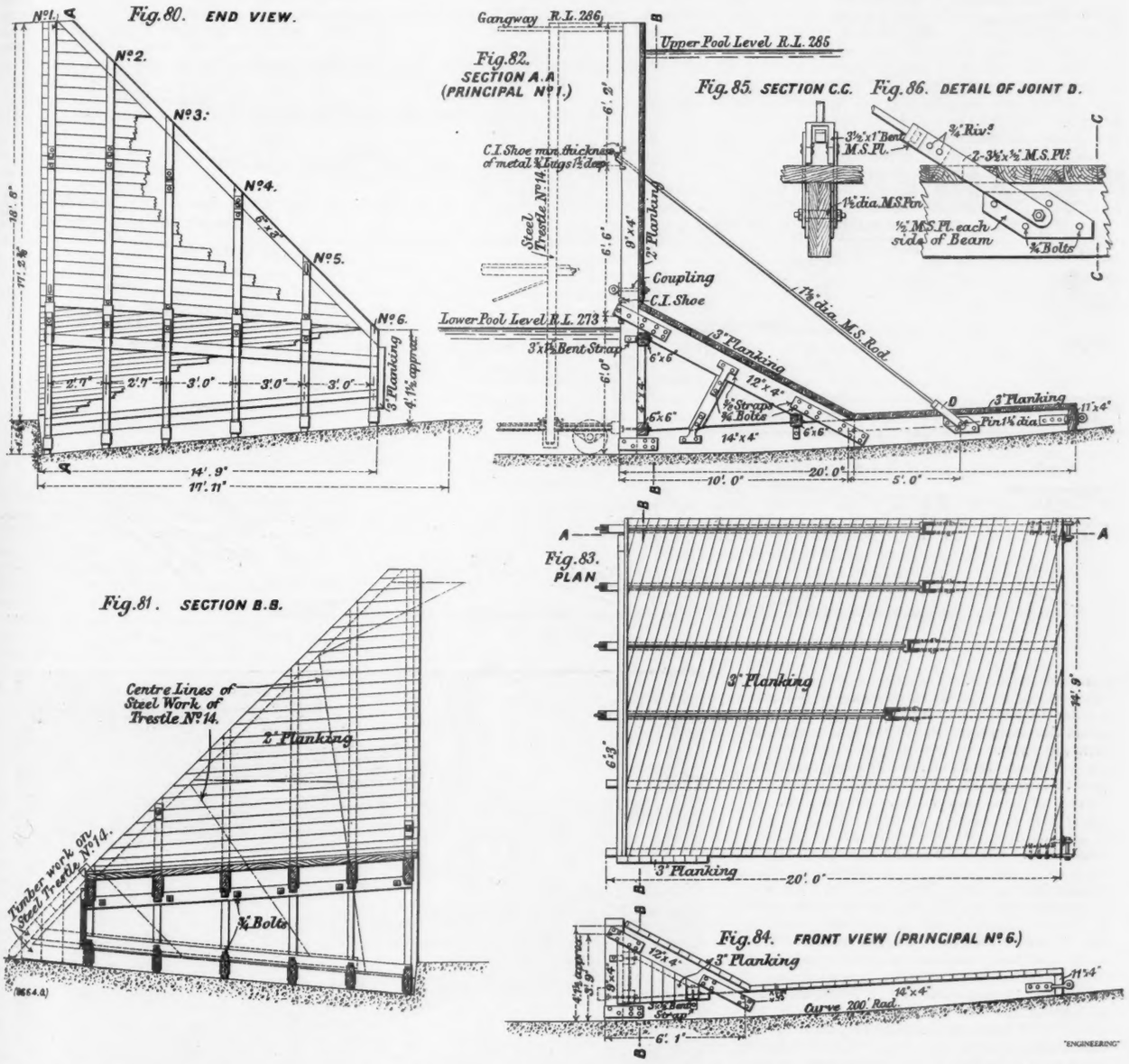
IN our last section we dealt with the standard type of lock which had been adopted in connection with the weirs on the Murray, and dealt particularly with that constructed at Torrumbarry, the farthest work up-river of all comprised in the present programme. We now propose to describe the weir at the same place, being indebted for the drawings, &c., and particulars of this to Mr. J. S. Dethridge, M.Inst.C.E., Commissioner for Victoria, who was responsible for the design. In this instance, as already recorded, it was decided not to adopt the Boulé or other type of weir involving parts permanently fixed under water, or concrete obstructions in the fairway. The consequence has been the evolution of what we believe to be an altogether novel design, which we illustrate in Figs. 52 to 86, on Plate XXXIV, which accompanies our issue of this week, and on this and the opposite pages. Briefly stated, the weir consists of a series of movable trestles placed across the fairway when water has to be held up, but drawn out of the channel up a long ramp when the flow of the river at time of flood is sufficiently great for the weir to be dispensed with. The final design was worked out after extended model experiments at Werribee. Before entering upon a detailed description we may perhaps refer to Figs. 25 and 50, on pages 468 and 470, of our last article. Of these the plan, Fig. 25, shows the lock on the left side of the new channel made for the river, cutting out a large loop. The weir is shown in position across the channel, while to the right will be observed the long ramp and platform up and on to which the weir trestles are drawn when not in use. The view Fig. 99, on page 546, shows the trestles in place in the stream, while Figs. 98, 100 and 101, on that page, give other views of the trestles to which we shall refer in detail subsequently. An elevation looking down stream is shown in Fig. 54, Plate XXXIV, where the general features referred to will be again recognised. To the right of the lock is a fairway of 327 ft. 3 in., closed by 14 trestle units. After a short vertical curve at the right-hand abutment wall comes the ramp, 187 ft. long, curving off at the top into a level stretch of 312 ft. Figs. 52 to 68, Plate XXXIV, all relate to the fixed structure. The depth of the upper pool is 16 ft. and the difference in level between the upper and lower pools when the next lower weir is completed will be 12 ft. As this work is not yet built, the Torrumbarry weir holds up at present a head of 15 ft. 6 in. This it has done quite successfully for two seasons. For the whole of this stretch of river there was no possibility of securing good foundations for the structure and the site was finally settled by the levels required for navigation, and the command of the irrigation area, referred to in our last article.

A section down the channel and across the work is given to a small scale in Fig. 53, while broken sections to an enlarged scale are shown in Figs. 52 and 56. Fig. 53 shows the whole length of the new channel cut across the neck of the loop. At the left is the old down-stream river bed into which the new cut debouches. At the right is the old up-stream bed and channel cut off by a piling and earthen dam with a crest level of 290 R.L. The sections in Figs. 52, 53 and 56 are all taken looking towards the ramp or slideway. In order to prevent risk of excessive leakage through the sandy formation beneath the stratum of clay on which the structure rests, the approach channel of the navigable pass was lined with reinforced concrete for a distance of 221 ft., terminating in a row of steel sheet piling. Reinforced concrete was also carried from the weir down stream for a distance of 201 ft., ending with a row of triple-lap timber piling. Thus any percolation water, when the weir is in operation, without allowance for deviation by the piling, or interception by the drainage system under the weir, would have to travel a distance of 422 ft. before it could pass from the up-stream to the down-stream pool.

The position of the lines of piling is shown in Figs. 52 and 53. The thickness of the concrete platform or raft, on the actual line of the weir, is 3 ft. This stretches over a distance of 43 ft. 6 in. Upstream of this is a run of 30 ft. having a thickness of 1 ft., beyond which again 6-in. concrete extends for 172 ft. 6 in. to the upstream piling. At the weir the reinforcement is of ½-in. rods arranged in 12-in. grids; for the rest upstream the reinforcement is of ⅜-in. rods placed in the same manner. For the last 16 ft. the concrete is laid on a 4 to 1 slope, the bottom of the approach channel being at 265 R.L., while the weir floor is at 269 R.L. Down stream of the weir the concrete protection consists of a run of 80 ft. of 2 ft. thickness, after which it is reduced for 20 ft. to 1 ft. thick, following which is 30 ft. only 6 in. thick. For the last 46 ft. the thickness is again increased to 1 ft., ending with a sloping section, inclined at 4 : 1, and finishing at the down-stream piling at 260 R.L. Beyond this is 40 ft. of boulder pitching. The reinforcement for all the down-stream end, save the 30-ft. length 6 in. thick, is of ½-in. rod. For the 6-in. thickness ⅜-in. rods are used; the spacing transversely and longitudinally is 12 in. The platform at the weir itself is arranged with a sunk ledge 1 ft. 5⅛ in. deep. This is formed by sloping the floor down from normal floor level to the depth named in a length of 17 ft. 9½ in. This ledge is shown in Figs. 52, 56 and 66. It runs completely across the bed, ending at the lock structure on the left side and at the work shown in plan in Fig. 57, on the right side.

As will be seen the latter consists of two walls at right angles, in front of one of which the weir floor is continued up a ramp on which three rails are laid. The arm extending down stream of the weir is shown in elevation in Figs. 52 and 56, and in section in Figs. 60 and 61. It is carried to a height of 17 ft. above the sill level, and is stepped at the back from 10 ft. at the base to 4 ft. 4 in. at the top. The positions of these sections are given, both in Figs. 56 and 57. Fig. 58 is a section along the ramp on the line DD in Figs. 56 and 57. Cross sections of the ramp and wall are shown in Figs. 62 and 63 at points also indicated in Figs. 57 and 58. The ramp is of concrete 12 in. thick reinforced with ½-in. rods in the form of 12-in. grids. The wing wall is 10 ft. wide at the base and 8 ft. 8 in. thick for the upper part near the river where provision is made for a footway sloping to a level

THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY WEIR.



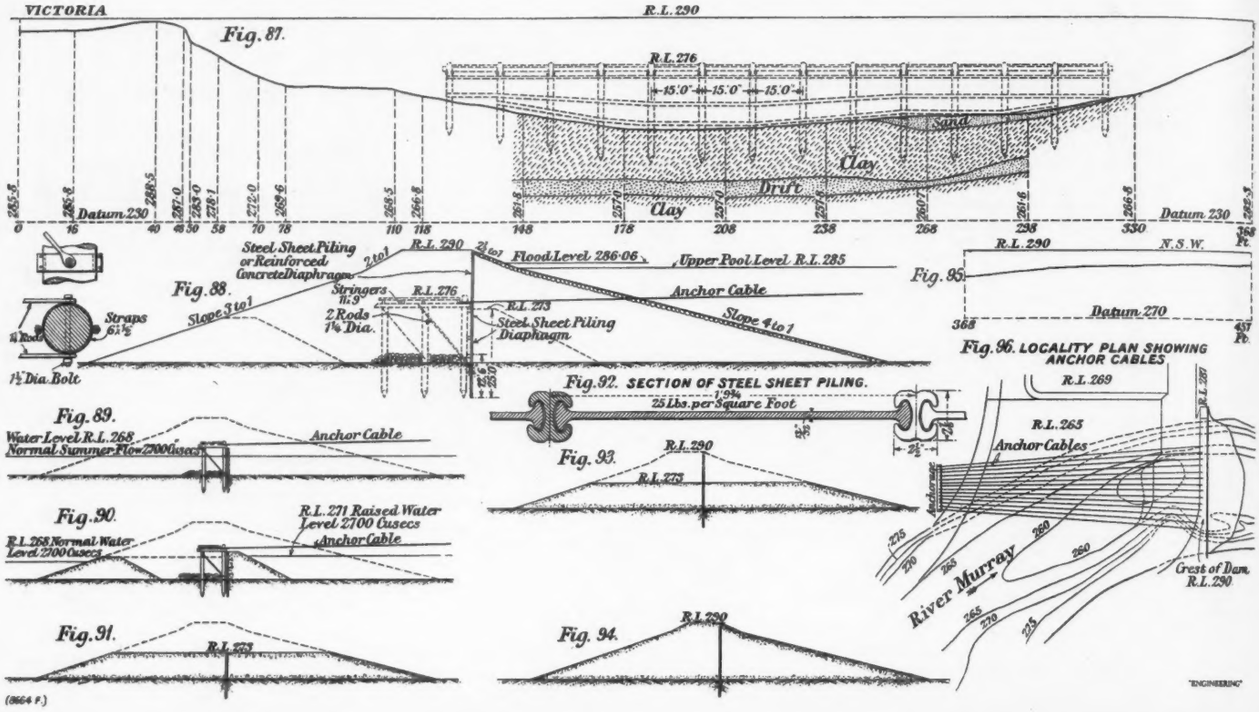
4 ft. 6 in. below the coping, and diminishing to the stepped section shown in Fig. 63 further up the ramp, running out finally into a wall 4 ft. 4 in. thick. The earthwork surrounding the structure is all raised to 287 R.L. On the down-stream side of the weir the wall top is finished with a 2 : 1 slope. This sweeps round into a 4 : 1 slope for the bank as shown in Fig. 57, the reinforced concrete protection for this bank being shown in detail in Fig. 55. It is laid 6 in. thick, and ends in a 5-ft. flat at the top and a 4-ft. sunk wall. On the up-stream side the bank of the channel is similarly protected, while further away from the weir, as at the section HH, Fig. 56, the 6-in. flooring is also run up the slope at the same thickness as shown in Fig. 59. Facing the ramp the earthwork is finished to a 2 : 1 slope, with reinforced concrete protection as shown in Figs. 62 and 63.

As indicated above, the ramp runs out into the level stretches at 269 R.L. and 288·5 R.L. by means of vertical curves. The weir floor is laid with three lines of inverted flat-bottom 60-lb. rails spaced 5 ft. 10½ in. apart as shown in Fig. 66, &c. These rails are carried up the ramp and end in a timber track laid on 9 in. by 4 in. by 15 ft. sleepers. A section of this is shown in Fig. 64. The left-hand abutment of the weir is shown in Figs. 65 to 68. Here the weir ends in the lock wall, a section of which is given in Fig. 67, the lock chamber being on the left and the weir on the right of the wall, which has a width of 14 ft. 9 in. This section is taken on DD, Fig. 66, which shows the wall face. Let into the face is a slanting slot to take the flash board ends of the last trestle unit (see Fig. 65). A plan of this abutment is shown in Fig. 68; this indicates the rail tracks laid in the floor, and also the system of 9-in. drainage laid under the weir floor and rising to the surface on the down-stream side, as shown in Fig. 66.

The movable units are illustrated in Figs. 69 to 79, and also in the views, Figs. 98 to 101, on page 546. Referring first to the latter, Fig. 98 shows a unit on the weir floor during the construction operations in the dry. Incidentally this view also shows the lock wall abutment and the slanting groove referred to above. Fig. 99 shows the complete weir in position across the channel. Fig. 100 shows a unit being hauled into position across the channel, while Fig. 101 shows all the units hauled up out of the channel on to the track described above. The main features of the units will be readily gathered from Figs. 69 to 73. There are fourteen of these units. All are 24 ft. long. They each consist of four vertical triangular frames, built up on a base of 6 in. by 5 in. by 25 lb. joists. The vertical triangular frames are also of similar sized joists and of 60-lb. rails, and 5 in. by 4 in. by ½ in. tees. The upstream face slopes at 45 deg. so that stability of the trestles under water pressure is assured without reliance upon the weight of the structure. Each unit is carried on fifteen small wheels running upon the three lines of 60-lb. inverted rails embedded in the weir floor. Four horizontal wheels also run along the 18-in. vertical face of the ledge. The load on the unit is transmitted vertically and horizontally to the weir platform through these wheels. The manner in which the wheels are carried in the frames will be clear from Figs. 69 to 71, while greater detail regarding the wheels running on the vertical face is given in Figs. 74 to 76 on page 532, and for those running on the weir floor in Figs. 77 and 78. The wheels are of cast iron and 18 in. in diameter by 4 in. face.

For the lower 4 ft. of vertical height the

TORRUMBARRY DIVERSION DAM; MURRAY RIVER.



flashboards are fixed. They are made of 12 in. by 5 in. red gum. This fixed planking is provided in order to ensure pressure on to the floor and against the ledge, being exerted as soon as the unit enters the water. Above this height the facing is of movable bars from 14 ft. to 18 ft. long and 3½ in. square. Through one end of each bar a ½-in. pin is driven so as to project ¾ in. from one side. In placing bars in position the ends with these pins are slid down a slot formed in every alternate trestle frame. When this end has been pushed down as far as it will go the bar is lowered sideways and forced down into its proper position, when they overlap as shown in Fig. 72. In the view reproduced in Fig. 98, bars will be seen being tried in position during erection. The projecting ends of the bars are not restrained in any way except by the effect of the water pressure. An advantage of this free end type of bar is that no fitting is needed as is necessary with panels guided in slots. No difficulty has been experienced either in removing or in placing these bars in position for the regulation of the river. At the left hand abutment the end of the bars are placed in the sloping slot in the concrete wall, already referred to, and shown in Figs. 65 and 66.

When the river is in flood, as shown in Fig. 79, the trestle units are kept on the track at the top of the ramp. When it becomes necessary to hold up the water, for navigation or irrigation, the units are hauled one by one into the river bed, along the track and ledge, by a steam winch and endless cable gear, extending right across the fairway from the ramp to a sheave on the lock wall. Fig. 100 shows one of the units being hauled into position. The tower to be seen in all the views we reproduced was, however, one used only for construction purposes.

A closing section is placed at the right hand end, to prevent water escaping through the end of the trestle framework. This closing section is shown in place in Fig. 99, page 546, and in detail in Figs. 80 to 86, page 533. It is of timber with iron straps, &c. Fig. 82 is a section taken in line with the track, the end trestle unit being shown dotted to the left of that drawing. The closing section consists of a triangular wall of planking carried by a vertical frame of quartering, and a floor frame, partly planked on the level and partly on the slope. The floor timbers are finished on the underside to a curve of 200 ft. radius so as to fit snugly down to the floor on the vertical curve where the ramp commences to rise. The design of this section is such that the water pressure holds it well up to the end trestle frame, hard down on to the floor, and also close up to the wall. This unit has no wheels.

When all the trestles are in position the necessary stop bars are placed in position from the gangway running along the top of the structure. When, with the approach of the flood season regulation is not required, the bars are removed and the units are hauled out of the channel one by one. Fig. 99 shows the trestles ready for hauling out. The operation of placing and withdrawing the trestles and bars each occupy about 40 hours with a gang of six men. Before the trestles are placed the weir floor is scraped with a drag made of 60-lb. rail drawn backwards and forwards in the groove by the winch and wire cable. So far the weir has given every satisfaction in service through two seasons of flood.

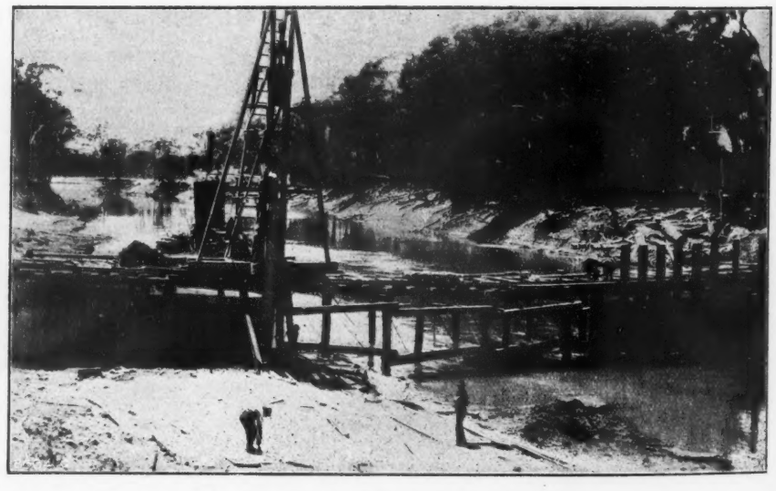


FIG. 97. DAM IN COURSE OF CONSTRUCTION.

When construction work on the Torrumbarry weir and lock was completed, to bring it into use after construction in the dry it was necessary to divert the river from its original channel round the bend into the weir bed, which had been cut for it. This was accomplished by placing the dam shown in Fig. 25, page 468 *ante*, across the original channel. This work is illustrated in Figs. 87 to 97, on this page. A section of the channel is shown in Fig. 87, and a small plan of the part involved in Fig. 96, the old channel curving off in this to the right while the approach to the weir runs off the top of the figure. The first work consisted in constructing a timber bridge across the bed, as shown in Figs. 87 and 88, and in the view reproduced in Fig. 97.

On the up stream side of this a row of steel sheet piling was then driven. Details of the piling used are shown in Fig. 92. Support for this was given by the bridge, and, in addition, 14-anchor cables were run from the bridge piles on to the left bank of the new channel, as shown in Fig. 96 and in Figs. 88 to 90. Stone protection was placed under the bridge, as indicated in Fig. 88. As the river bed was considerably lower than the sill of the weir, it was necessary to leave openings in the diversion work for the passage of the water, while the piling was being driven. This was arranged for by cutting the alternate sheet piles into two sections. After driving these together, the upper parts were withdrawn slightly, allowing the water to pass through the openings thus formed without producing scour. Piles thus raised can be seen to the right of Fig. 97. When the line of sheet piling was complete, and all other work was ready, the half-piles were quickly driven home and the water was allowed to rise and flow down the new channel over the navigable pass of the weir.

The next stage of the operations is indicated in Fig. 90, and consisted in forming a bund across the river on the down stream side, and also filling in on the up-stream side of the row of piling. The down stream bund corresponded with the intended position of the toe of the completed work. The pool between it and the upstream filling was then pumped out, and the stone protection under the bridge removed. Subsequently, filling proceeded until the earthwork assumed the final form up to 273 R.L., the timber bridge being removed as the work proceeded, and the up-stream face being pitched with rock on a 4 : 1 slope. The height at this stage was sufficient to take care of normal summer flow. The next stage (Fig. 93) consisted in completing the steel piling to 290 R.L., and the whole work was finished, as shown in Fig. 94, by filling to the same level, the top of the up-stream side being faced to a pitched slope of $2\frac{1}{2}$: 1, and the down-stream faced to slopes of 3 : 1 and 2 : 1.

In the opening article of this series we stated that the works on the Murray for the stretches for which it forms the boundary between New South Wales and Victoria, were to be constructed jointly by these two States. Actually it has been found more convenient to make rather different arrangements. Except for the Hume reservoir the works have been built either by one State or the other as has happened to be convenient from the proximity of important townships on one side or the other of the river. Thus the Torrumbarry weir and works near Mildura, in Victoria, have been in the hands of that State, while New South Wales is undertaking works near Wentworth, thus securing in all these cases reasonable transport facilities, &c. The joint work on the Hume reservoir will be dealt with in our next article.

(To be continued.)

LITERATURE.

The History of Munitions Supply in Canada, 1914–1918. By DAVID CARNEGIE, C.B.E., M.Inst.C.E., &c. Hon. Colonel Canadian Militia; Ordnance Adviser of Shell Committee and Imperial Munitions Board. London Longmans, Green and Co. 1925. [Price 18*s.* net.]

THE policy pursued by the military authorities in this country during the Great War tended to the suppression of all information concerning the organisation of the munitions service and the extent of production. Doubtless there were good grounds for this extreme reticence, but it was attended by the unfortunate result that few were able to appreciate the exertions made by expert and amateur workers, and to recognise the wealth of patriotism and self-denial that were rendered without stint, and, it is feared, in many cases accepted without reward. It is well, therefore, that, after a considerable lapse of time that enables a correct perspective view to be taken of a period of fierce excitement when actions were misrepresented by passion and distorted without reason or evidence, that Canada, who laboured with feverish energy on behalf of the Empire, should put out a plain statement of what she achieved, in face of many difficulties, to furnish the army with the munitions of war. Great as was this contribution in many directions, great as was the sacrifice Canada accepted in equipping the contingent of men and officers—a contingent which, it will be remembered on a momentous occasion, "saved the situation,"—far greater is the demand on our gratitude and recognition for the readiness with which all classes devoted themselves to the common end of attaining victory, and with it assuring national security.

It is fitting that we should know from one intimately connected with the whole machinery of production what this nation, small in numbers, but rich in patriotism, energy and resource, did effect in the provision of shells, cartridge cases, fuses, explosives, ships, aeroplanes and other munitions of war, that unfailingly fed our armies on sea and land throughout the long contest. Carefully compiled statistics may enable one to follow, and in some faint measure to grasp, what was achieved by indefatigable energy and unfailing resource. But a greater effort of imagination is necessary to estimate the ingenuity and organisation which brought to a successful issue, enterprises that had never been attempted in the Dominion. Basic open-hearth steel, or a very satisfactory substitute, was obtained from the red hematite ores. The necessary plant for the production of high explosives was evolved, and methods of manufacture initiated. The wooded slopes of the Pacific coast were searched for suitable timber for the construction of aeroplanes, and the noblest trees were devoted to the purpose; flying corps arose as by magic and aeroplanes were carried over the Atlantic by the thousand; steel ships were built on the Atlantic coast, and wooden craft on the Pacific. The catalogue might run on indefinitely and not be exhausted, for the whole country appears to have been turned into an arsenal, where men and women vied with each other to leave nothing undone to enable the soldiers of the Empire to meet the foe with a balance of advantage on their side.

Canada, let us remember, is an agricultural country; the ambition of her sons is to cultivate the soil, and their pride, as their reward, is in the golden grain and fruit-laden orchards that adorn her wide-spread plains. What induced a nation so nurtured in peace and husbandry to adopt the martial attitude and to maintain it with courage and determination to the end? The arsenals were insignificant, military display had never excited the people, and the raw materials for munitions were supplied by the United States. At the earliest requests from the Home Government it was indeed still necessary to purchase some of the needed materials from that country. From this necessity arose the insinuation that the United States were exploiting the needs of Canada and the Empire to their own advantage. There is no evidence of such profiteering here, and fears that were entertained both at home and in the Dominion, that public opinion and German interests might force the United States Government to place an embargo on certain indispensable goods, were equally groundless. It would be doing the author an injustice if we omitted to direct attention to his generous acknowledgments of the ready assistance rendered by the manufacturers of the United States. "Those," says Colonel Carnegie, "who had actually to deal with the Americans know the fine type of men who stepped in at great risk and supplied machinery, tools, gauges, as well as materials in 1914," and that at a time when the German fires burned fiercely in the hotels of New York, Pennsylvania and even Chicago.

There is little use in entering into statistics because we cannot understand what is meant by millions and hundreds of millions. The point we want to make is that feverish earnestness animated all classes; men and women, trained and untrained, threw themselves into the task of production. Of course, Col. Carnegie deals amply with both the statistical and the financial side, and in so doing makes it clear that the huge task was made possible only through the happy combination of employers and employed, engaged on the work, each giving to the other loyal and mutual aid. Incidentally we may note that the enormous mass of shell and projectiles did not prove so deadly as in the old days, when the forces engaged were smaller and arms of precision as we understand the term were unknown. In the time of Marshal Saxe and such heroes, it was said that it took a man's weight in lead to kill him, but from the weight of projectiles furnished from the Canadian centre alone, it is evident that a very great proportion fell harmlessly among the foe. The main outcome can be put in the words of Sir Sam Hughes, who pointed out, that under the energetic and intelligent control of Sir A. Bertram, "the result had been nearly 400 million dollars worth of business for Canada: 100,000 Canadian workmen trained to be skilled; millions of shells to the front; the furnishing an example and model for all lands; prosperity in Canada and not one law suit."

This last clause emphasises the self-denial and generous response from all sides which characterised the undertaking. Friction there may have been, and notwithstanding the author's recital, we fail to understand why the Shell Committee was deposed in favour of the Imperial Munitions Board. It is to be feared that there was some heartburning over the substitution and implied disapproval of some who had worked earnestly, when the strain was at its worst and the demand keenest. But under the tactful guidance of Mr. W. L. Hitchens, the reconstitution proved that the more the personnel changed, the more it was the same thing—one in loyalty, and devotion, in determination and achievement.

Another side of this warlike display may be glanced at with advantage. Canada was not without compensations. Her natural resources advanced in a most encouraging manner, in fact, at a percentage rate that exceeded that of any producing nation. Her capacity to produce steel and whatever was necessary for the prosecution of the war was amply demonstrated and the scientific knowledge acquired remains a very permanent asset. The value of hydro-electric power was shown by the demands made upon it, and its influence as a factor in manufacture is reflected in the national development. The country grew to manhood and learnt what it could achieve. An impetus was given to many operations, especially in metallurgy, as the output of copper, nickel, zinc aluminium, antimony, &c., amply demonstrates.

Nickel and its Alloys. Circular of the United States Bureau of Standards. No. 100. Department of Commerce, Washington. *2nd* Edition. Revised May 9, 1924. [Price 40 cents.]

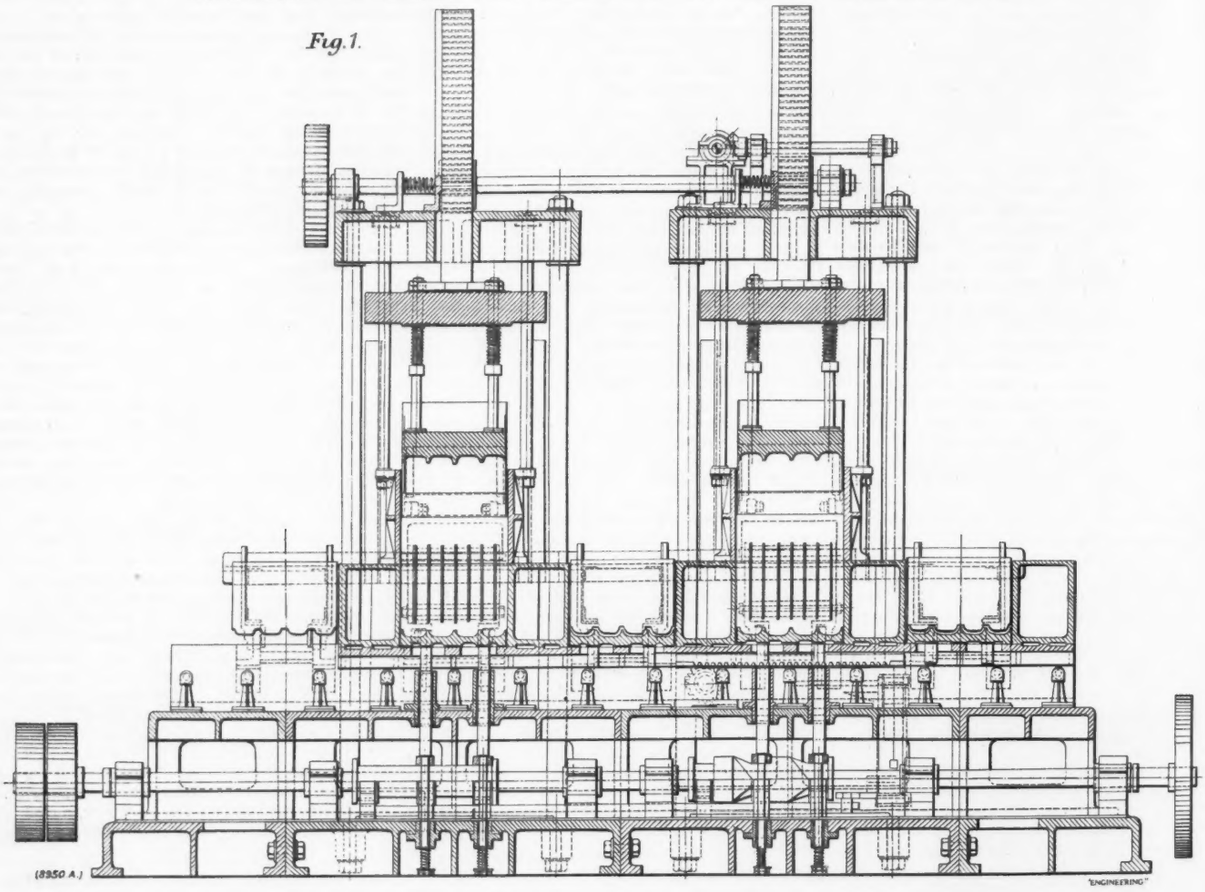
IN the course of his speech delivered at the opening of the Empire Mining and Metallurgical Congress on June 3, of last year, the President, Viscount Long, stated that nickel was a metal which had been much discussed during the war because of our failure to control the entire refining of the nickel ore output of the Empire. An overwhelming proportion of this metal was made in Canada, and in the last years of the war, when production rose to the record figure of 46,253 short tons, the Dominion's contribution was 87 per cent. of the total output of the world. Last year Canada contributed 69 per cent. and New Caledonia 25 per cent. of the world's total. In Canada numerous deposits of nickel ore are known, but only the nickeliferous pyrrhotite deposits of Ontario have as yet been worked. The deposits of the Sudbury region on the north side of Lake Huron are the largest and richest in the world. The ores as mined contain an average of 3·09 per cent. of nickel and 2·12 per cent. of copper. The bulk of the refining is now done locally, a result due to the war. A conservative estimate of the proved ore in 1916, published by the Ontario Nickel Commission, placed the total at 70,000,000 tons, with a further 80,000,000 tons probable.

We referred to nickel and its ores in our issue for January 25 of last year, when dealing with a publication by the Mineral Resources Committee of the Imperial Institute giving data on the nickel ore resources throughout the Empire and on the uses of the metal. Another publication of a similar nature is the work mentioned in the title above, the object of which is to group together the information which the American Bureau of Standards has made available as a result of its tests and investigations, and to record at the same time the information to

MASTRACOAL BRIQUETTING PLANT.

CONSTRUCTED BY MESSRS. G. D. PETERS AND CO., LIMITED, ENGINEERS, SLOUGH.

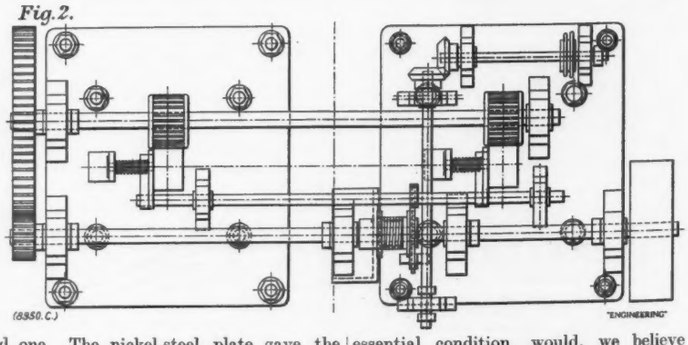
Fig. 1.



be gathered from work done outside the United States.

This compilation says that the principal industrial use of nickel is in the manufacture of nickel-steel, this industry having absorbed fully 75 per cent. of the total nickel production during the war. The normal consumption for the manufacture of nickel-steel amounts to about 65 per cent. In regard to nickel-steel reference is made to the paper read before the Iron and Steel Institute by the late Mr. James Riley in May, 1889, a paper which was based on preliminary researches carried out in France, indicated the possibility of manufacturing nickel-steel on a large scale in the open-hearth furnace, and created much interest at the time amongst metallurgists, engineers and naval architects in this country. When this paper by Mr. Riley is quoted reference should also be made to the discussion which it gave rise to. In this, the late Mr. J. F. Hall, of Messrs. William Jessop and Sons, Sheffield, took part, and stated that he had been working for a long time before 1889 at the manufacture of nickel-steel in the crucible; he had been granted letters-patent at the beginning of 1888 for the use of nickel in steel from 2·5 to 50 per cent. He had manufactured gun barrels of nickel-steel, and out of a series of four propeller blades he had made one of that alloy, the three others being of ordinary steel to compare them together for corrosion. Further, it is on record that the tentative manufacture of nickel-steel on a large scale in the open-hearth furnace commenced in France in June, 1888; regular manufacture started there in March, 1889, before the date of Mr. Riley's paper. In this connection it may be interesting to recall that armour plate firing trials took place at Annapolis, U.S., in September 20 to 22, 1890, of a French nickel-steel plate, a French "all-steel" plate and a compound one. The nickel-steel plate gave the best results.

Fig. 2.



The work under notice enters in detail into the non-ferrous alloys of nickel, about 15 per cent. of the world's production of the metal being used in the manufacture of these alloys, such as cupro-nickel and nickel-silver. It also gives particulars concerning malleable nickel for rolling into sheets or rods, and for drawing into wire; 5 per cent. of the world's production is used in this way, all malleable nickel before casting into ingots being treated with some deoxidiser, generally magnesium. Nickel castings have been used with great success as rabble shoes in calcining furnaces for roasting nickel matte; the shoes are exposed to oxidising and sulphurising gases at temperatures ranging from 600 to 1,000 deg. C., and to severe mechanical abrasion. They have stood up to this service for nine months, whereas cast-iron shoes last no more than from six to eight weeks. Nickel steel supports in furnaces for large advertisement sheet enamelling, where great cleanliness is an essential condition, would, we believe prove a success if not already used in that trade, in the place of ordinary iron supports.

A large amount of information is also given on the various patent non-ferrous nickel alloys; this, together with a most complete bibliographical index, renders the compilation of special value.

THE MASTRACOAL BRIQUETTING PROCESS.

THE practice of forming coal dust, and other similar refuse fuels, into blocks or briquettes, which can be conveniently handled and burnt in furnaces or in open grates, has been carried on for many years, and has developed into an important industry, notably in South Wales. The coal dust is usually mixed with a certain proportion of pitch, or with some proprietary binding material of a similar character, heated by steam and stirred in a paddle mill, and then delivered to a briquetting

MASTRACOAL BRIQUETTING PLANT.

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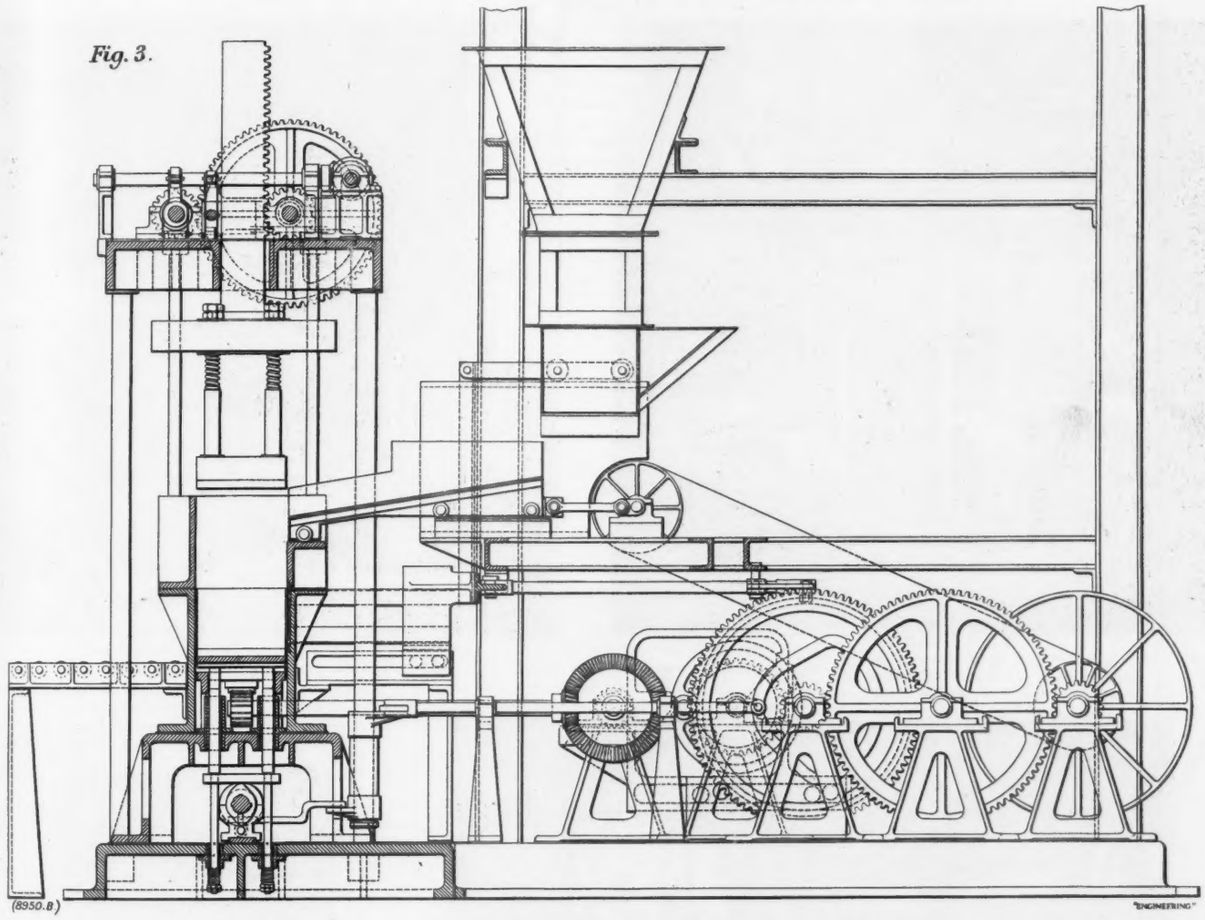
Fig. 3.



machine, in which the heated mixture is formed into blocks under considerable mechanical pressure. Unless this operation is carried out with due care, the briquettes are found not infrequently to burst open when released from the moulds of the briquetting press, owing to the expansion of the imprisoned steam, and it is by no means uncommon for them to break up if exposed to the weather for long. Trouble is also occasioned to users by the fact that briquettes sometimes fall to pieces in the fire as soon as the outer shell has been consumed, the pressure applied during manufacture, or the proportion of binder employed, having been insufficient thoroughly to consolidate the interior.

The process which we now propose to describe, known as the Mastracoal process, has for its object the production of briquettes free from the above-mentioned defects, as well as the reduction of the proportion of binding material used to a minimum. The process has been introduced by Messrs. Macnab Stratified Coal, Limited, 119, Victoria-street, Westminster, S.W. 1, and the plant, which we illustrate in Figs. 1 to 7, on this and the opposite pages, and on page 538, was designed by Mr. J. S. Harrison, of that company. It is installed, for demonstration purposes, at the works of Messrs. G. D. Peters and Co., Limited, Slough, who undertook its construction.

The essential feature of the process is that the fuel dust, after being mixed with binder and heated by steam in the ordinary way, is delivered into the mould of the briquetting machine, and there subjected to a violent vibratory motion while under slight pressure from a weight resting on the top of the material. The effect is, apparently, to cause the grains and larger fragments to move relatively to each other so that they fit closely together and the voids are completely filled. The close contact of the particles brought about in this way, it is claimed, enables satisfactory briquettes to be produced with a smaller proportion of binder than is required for briquetting by pressure alone, and, moreover, since the vibration affects the whole of the material in the mould, the central portion is thoroughly consolidated. This is shown in Fig. 7 on page 538, which illustrates a briquette made by the Mastracoal process, and afterwards split into two equal parts. This particular briquette was made from Durham steam coal, with 6 per cent. of pitch.

Drawings of the briquetting machine are reproduced in Figs. 1 to 3, while Figs. 4 to 6 illustrate the complete demonstration plant at Slough. The arrangements used for supplying the machine with raw material and for the delivery of the finished briquettes call for no special comment, as they would naturally differ in particular installations in accordance with the quantities handled and the requirements of each case. In the demonstration plant, the coal dust and broken pitch are dumped into the hopper shown in Fig. 5, and delivered by a bucket elevator into a paddle mill mounted above the machine. The mill is supplied with steam at a pressure of 100 lb. per square inch, superheated to 500 deg. F., which heats the material and melts the pitch, the whole being continuously stirred by the rotating paddles. From an adjustable sliding door in the bottom of the mill the mixed material falls continuously into a hopper shown in Fig. 3, and at the bottom of this hopper is a rectangular measuring box, the capacity of which is about equal to that of the mould of the briquetting machine. The bottom of the box is fixed, but once in every cycle of operations involved in the production of a briquette, the sides are moved forward, *i.e.*, to the left in Fig. 3, so as to deliver the contents on to an inclined reciprocating chute clearly shown in the illustration. The bottom of the hopper is closed when the box moves forward by a horizontal steel plate attached to the back of the box as shown, in order to prevent the material in the hopper from falling out. The reciprocating motion of the inclined chute on to which the measured quantity of mixed material falls, serves to assist the movement of the material down the chute which delivers it into the mould of the briquetting machine, and also to facilitate the escape of any free steam from the mixture. Guide plates are fitted on the upper edges of the mould proper as shown in Fig. 3, and also in Fig. 1.

From the latter it will be seen that the sides of the mould are formed by steel box castings and that the moulds, two of which are provided for each briquetting unit, are mounted on a table supported on rollers running in pedestals bolted to the bed of the machine. The front and back of the mould are formed by cast-steel plates fixed to the bed of the machine, and the bottom, in each case, is formed by a loose plate of gun-metal of the section illustrated in Fig. 1. At an appropriate moment in the cycle of operations, the table is moved laterally to bring an empty mould under one of the heads of the machine and to allow the finished briquette, which has been formed as we shall shortly explain, to be pushed out. An inspection of Figs. 1 and 3 will show that the bottom plates of the moulds are each fitted with four short steel rods, which pass down through holes in the table, and, when the mould is in position under the head of the machine, these rods rest on the ends of four vertical steel

MASTRACOAL BRIQUETTING PLANT.

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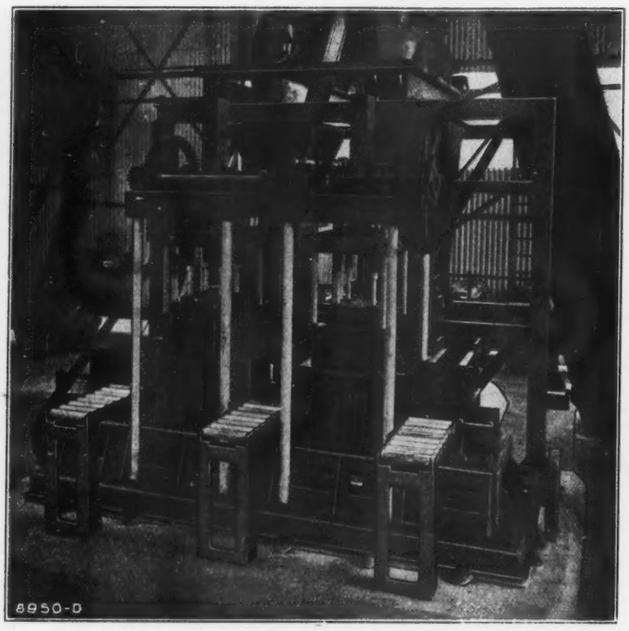


FIG. 4.

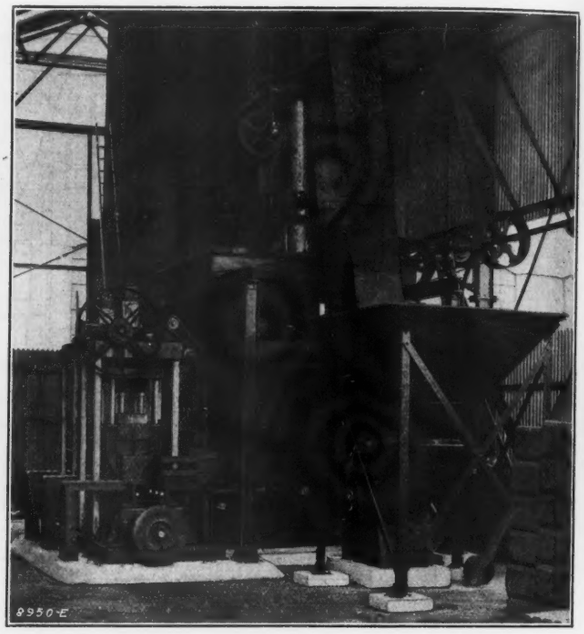


FIG. 5.

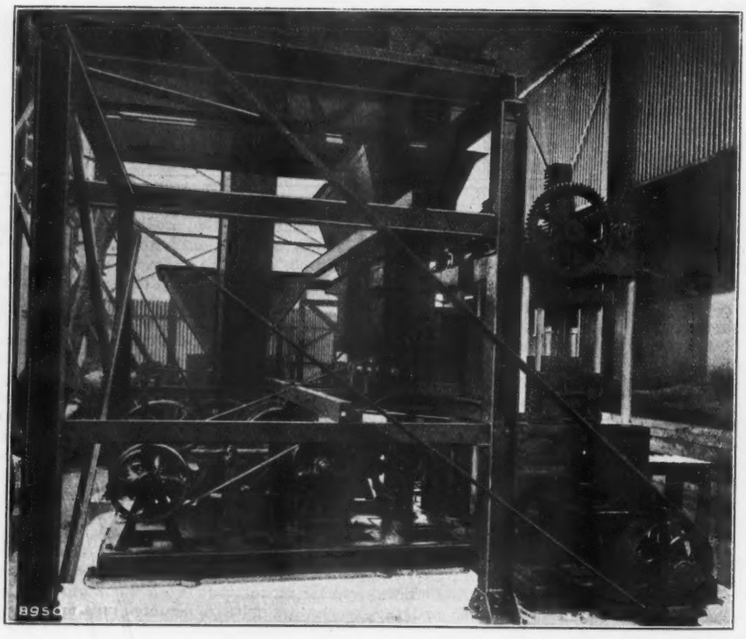


FIG. 6.

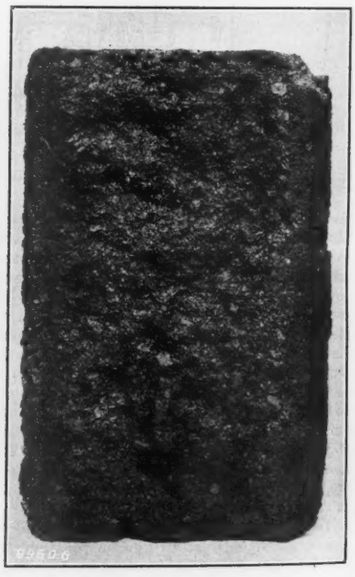


FIG. 7.

plungers attached to a hardened-steel plate. The latter bears on a cam mounted on a splined shaft running in the bedplate of the machine, and, by sliding the cam along the shaft, a vertical vibratory motion can be imparted to the plungers and consequently to the bottom plate of the mould. The cam, it should be noted, is supported in half bearings which rest on the bedplate and slide along the latter when the cam is moved, in order to relieve the shaft of bending stresses. The vibratory motion is in operation while the mould is being filled, and when the filling is complete the top plate of the mould, which is also of gun-metal and similar to but heavier than the bottom plate, is allowed to fall on to the material in the mould so as to compress it.

As will be seen in Figs. 1 and 3, the top plate is connected by four rods to a rectangular plunger, on one side of which a toothed rack is fixed. The rack engages with a pinion on an overhead shaft, shown in Figs. 1, 2 and 3, and this shaft is driven through a coil clutch which is automatically engaged and disengaged in the course of the cycle of operations, so as to raise the plunger of each unit alternately and then allow it to fall together with the upper plate of the mould; the driving shaft, of course, rotates in the reverse direction while the plunger is falling, being driven by the rack. It will also be noticed from Figs. 1 and 3, that a heavy cast-iron weight is fitted on the four rods connecting the upper plate of the mould to the plunger, the weight sliding freely on the rods and being supported by helical springs encircling them. Four rods, also passing freely through holes near the corners of the weight, are provided as shown to guide its movement.

Having now described the essential features of the machine we may explain the series of operations involved in the production of a briquette, referring to one unit only, although it will be understood that the operations are carried out simultaneously on each

unit. The first operation is the moving forward of the measuring box to deliver the material into the inclined chute, and at the same time that this movement is made the cam on the shaft in the bed-plate is moved along to set the bottom plate of the mould vibrating. When the mould is filled, the upper plate, together with the plunger and spring-supported weight, falls, and comes to rest on the material in the mould, compressing it by the kinetic energy and deadweight of the falling parts; the pressure due to the weight, it may be mentioned, amounts to 4 or 5 lb. per sq. in., as compared with a pressure of 2 or more tons per sq. in. employed in an ordinary briquetting press. The vibratory motion of the bottom plate, which still continues, is transmitted through the material in the mould, causing the upper plate also to vibrate, but the vibration of the latter is resisted and a steady pressure maintained for a few seconds by the weight acting through the helical springs. The top plate and the weight are then raised clear of the mould and guide plates, and the cam operating the vibratory motion of the bottom plate is moved clear sideways so that the motion ceases. The travelling table carrying the moulds is afterwards moved laterally by rack and pinion gearing to bring the mould containing the finished briquette opposite one of three pusher plates shown between, and on each side of, the two units in Fig. 1. Finally, the pusher plates are moved forward delivering the briquette on to one of the short roller tables, clearly shown in Fig. 4, opposite. In the demonstration plant, the briquettes are removed by hand for cooling and stacking, but in a working installation some more convenient and expeditious and method of handling them would, of course, be adopted. The forward movement of the pusher plate, it may be mentioned, coincides with that of the measuring box, so that as one briquette is delivered the filling of another mould is commenced, the cycle of operations, which takes about 20 seconds, being carried on continuously. The briquettes are delivered alternately on opposite sides of each unit, and, in the two-unit machine illustrated, are produced at the rate of about 9 tons per hour. For commercial work, however, four-unit machines would be supplied with double the above-mentioned capacity.

The briquettes produced at the demonstration plant weigh from 50 lb. to 56 lb. each, measuring 14 in. by 12 in. by 7½ in., such large briquettes being more difficult to consolidate thoroughly by the processes in common use than are smaller ones. The moulds can, however, be readily subdivided to produce briquettes of any smaller weight or shape. Another method by which briquettes of comparatively small weights and dimensions can be produced is shown fitted to the machine illustrated in Fig. 1. As there shown, the back plate of the mould is slotted and a set of seven vertical knives mounted on the pusher-plate operating gear is arranged so that the knives can pass through the slots into the mould, dividing it into eight equal parts. The knives are in position while the mould is being filled and while the contents are being vibrated, but are withdrawn before the top plate is allowed to fall. Their effect is to produce planes of cleavage in the finished briquettes, which can thus be broken up locally for consumption more readily than would otherwise be the case.

The machine illustrated is driven by a 12-h.p. motor, but about 50 h.p. would be required for the operation of a complete four-unit plant, including the elevators, conveyors, &c. The driving arrangements can be followed from Figs. 1 to 3 and from Fig. 6, opposite, with but little explanation. The belt pulley on the right of Fig. 3 runs at 75 r.p.m., and the shaft on which it is mounted is connected by belt, as shown, to a pulley driving the reciprocating chute by means of a crank. The camshaft is separately driven by belt, as shown in Fig. 1, the shaft running at 300 r.p.m., and the lateral movement of the cams is effected by a rocking lever, crank, and push rod, from a cam slot on the side of a drum driven by reduction gearing from the main driving shaft; the arrangements are most clearly shown in Fig. 3. On the periphery of this drum, is a cam operating the pusher plates and feed boxes simultaneously, and the lateral motion of the table carrying the moulds is obtained from a rack connected to a reciprocating yoke, the rack engaging with a pinion which drives the pinion of the table-operating gear through a pair of bevel gears. The overhead gear controlling the rise and fall of the plungers and top plates of the moulds is separately driven by belt from the line shafting, but the clutch-operating mechanism of this gear is driven by chain from the shaft on which the cam drum, above referred to, is mounted; the chain can be distinguished in Fig. 5.

A wide range of fuels, including anthracite breaker duff, bituminous coal, coke breeze, South African coal, Australian brown coal, Spanish lignite and washery slurry, has been successfully briquetted at the demonstration plant, the proportion of pitch binder varying from 6 per cent. by weight in the case of bituminous coal to 12 per cent. with coke breeze. The resulting briquettes, it is claimed, give satisfactory results for boiler firing, including locomotive boilers, and also burn well in open grates, the large briquettes, of course, being broken up by hand for the latter purpose. To test their resistance to shock, briquettes weighing 50 lb. each and made from Durham steam coal with 7 per cent. of soft medium pitch as binder, were dropped from a height of 8 ft. on to a solid concrete floor. The portion remaining on a screen with 2-in. openings was dropped again, and the process of dropping and screening alternately in this way was repeated four times. As a result of this treatment, the proportion of fragments exceeding 2 in. in dimensions amounted to 80 per cent., this portion having been dropped four times in all. The remainder consisted of 8 per cent. of between ½-in. and 2-in. size and 12 per cent. of smaller fragments and dust. In compression tests the same briquettes have been found to fracture along straight lines at a load giving a stress of about 250 lb. per square inch, and other tests have shown the porosity to be considerably less at the centre than at the surface.

Briquettes exposed for several weeks in an open yard in very wet weather, we understand, have shown no signs of disintegration. As a further test of the weathering properties, a briquette made from Scotch coal with 8 per cent. of binder, which had been immersed in water for about 8 weeks, was placed, at our suggestion, in a refrigerator and there maintained at a temperature of 28 deg. F. for four days and nights. It was then removed and thawed out without crumbling or splitting either generally or on the surface, the briquette, in fact, remaining in the same condition as it was before freezing. This would appear to indicate that very little water had been able to penetrate below the surface of the briquette during the course of the long immersion to which it had been subjected.

In conclusion, we may mention that a number of briquetting plants, on the system described above, are now being put down in different Continental countries for operation on a commercial scale.

THE DENSITY AND CONSTITUTION OF THE INDUSTRIAL BRASSES.*

By G. L. BAILEY, M.Sc., A.I.C., and R. GENDERS, M.B.E., M.Met., F.I.C.

Communication from the Research Department, Woolwich.

THE significance of density has been considerably widened as the result of recent progress made towards the delineation of the internal structure of crystals. From the practical, as well as the theoretical point of view, however, knowledge of the densities of metals and alloys is becoming increasingly important, since it provides means for a quantitative measure of unsoundness in castings and of net volume change in heat-treated alloys.

Little work has been directed to the density of the brasses, and the majority of the records available are of doubtful accuracy and show little agreement. A detailed summary of the earlier work has been given by Bamford,† who carried out a comprehensive series of determinations on chill- and sand-cast brasses. Bamford's results were intended to serve as standard values for sound castings, with which the densities of industrially manufactured chill- or sand-castings could be compared, and were determined with a high degree of accuracy. The main point of criticism of the work was that some uncertainty existed as to whether the samples used were perfectly sound, and that the state of the alloys relative to equilibrium was not defined.

The authors have made extensive use of the density method of determining the degree of unsoundness in brass castings containing between 65 and 75 per cent. copper, and during the course of their work have found many instances where the density of a casting has been slightly higher than the value interpolated from Bamford's figures. It was also observed that, in some cases, a sample of rolled annealed strip was lower in density than parts of the ingot from which it was rolled. On annealing the original density cylinders from the ingot, the density fell to that of the strip, or below. On quenching samples of the strip, the density rose to a value above that of the original chill-cast ingot. A few selected results, given in Table I, show the type of variation which occurred. The ingots had been chill-cast, and contained β which disappeared on annealing, and it was apparently this alteration in constitution which gave rise to the fall in density. It was evident that standard values for sound chill-cast brass must be limited in application unless definite conditions could be laid down.

TABLE I.—*Variation in Density between Rolled Annealed Strip and Original Ingot and the Effect of Heat Treatment.*

Copper. Per cent.	Density of Strip.		Density of Ingot.	
	Annealed 500 deg. C.	Quenched 800 deg. C.	Chill-Cast.	Annealed 550 deg. C.
64·6	8·393	8·441	8·429	8·398
64·6	8·380	8·443	—	—
62·6	8·358	8·416	8·394	8·377
62·6	8·361	8·426	—	—
62·2	8·367	8·418	8·402	8·377
62·2	8·360	8·413	—	—
61·9	8·353	8·412	8·388	8·354
61·9	8·363	8·414	—	—

The research now described was undertaken with the object of establishing, with accuracy, the crystal density of the copper-zinc alloys over the range of composition used industrially, and to determine the effect of change in constitution on density, with particular reference to the alteration in volume involved in the change of β to α.

Preparation of Materials.—Ingots 9 in. by 2 in. by 1 in. in dimensions of alloys made from B.E.R. copper (99·977 per cent. copper) and electrolytic zinc (99·952 per cent. zinc) were carefully cast in iron moulds. The seven compositions used (Table II, p. 540) covered the range 90 to 52 per cent. copper; the steps were widely spaced over the copper-rich alloys, and more narrowly spaced over the range 70 to 60 per cent. copper. Each ingot was rolled without annealing to a slab measuring 12 in. by 2·3 in. by 0·6 in., from which transverse sections were cut and turned to cylinders 0·5 in. in diameter and 1·5 in. in length. Sections from the ingots, as cast, showed no visible signs of unsoundness. It was considered advisable, however, to apply a small amount of cold-work in order to ensure the absence of cavities. The rolling applied was insufficient sensibly to affect the density apart from the removal of unsoundness, and the observed densities may therefore be taken to indicate the values given by perfectly sound chill-castings. Chemical analyses were made on samples from the top and bottom of each slab.

In order to extend the series to pure copper, available samples of a pure alloy, in the form of rolled annealed strip, which contained 96·5 per cent. copper, and of an exceptionally pure copper strip (99·987 per cent. copper), were utilised.

Micro-examination, carried out on a number of sections from each slab, showed a cored α structure in the alloys above 71 per cent. copper. Below that composition β was present, increasing in amount as the copper content decreased. The 52 per cent. alloy consisted solely of β.

Determination of Density.—The usual method of weighing in air and water was used. All the necessary precautions, such as the elimination of air from the distilled water and from the surface of the specimen during immersion, the swinging of the balance from a set position, &c., were observed, and the values for density were calculated according to the generally adopted formula:

$$\Delta = \frac{m}{w}(Q - \lambda) + \lambda.$$

The figures given represent the absolute density in grms. per c.c.

Duplicate determinations could be made on the same specimen at different times to within an accuracy of 0·002 absolute value, and the determinations on a number of specimens were checked in another laboratory. These agreed with the author's values within an average difference of 0·002, with a maximum difference, on one specimen, of 0·004. The figures given in

* Paper read before the Institute of Metals on Thursday, March 12, 1925.

† See ENGINEERING, vol. cxii, page 585.

the present paper may be taken to be subject to an experimental error of 0·002 absolute value.

In Table II. are given the summarised results for the individual densities of the whole of the cylinders from each of the slabs. The variation shown is extremely small, on the average of the order of 0·003, or 0·001 greater than the experimental error.

A uniform practice was made of employing duplicate specimens of each ingot for each experimental treatment and subsequent density determination. In no case did the values differ by an amount appreciably greater than the experimental error. Each figure given is the mean of the duplicate tests.

TABLE II.—*Composition and Density of Experimental Specimens.*

Copper Content of Ingot. Per cent.	Numbers of Cylinders Tested.	Average Density of Cylinders (Cast and Rolled Condition).	Maximum Difference.
99·99	2	8·933	0·000
96·50	2	8·886	0·003
90·00	10	8·795	0·002
80·20	10	8·657	0·006
70·00	10	8·512	0·004
65·20	18	8·457	0·003
62·00	17	8·410	0·002
59·80	18	8·382	0·002
51·70	10	8·292	0·003

Fig. 1. DENSITY OF COPPER-ZINC ALLOYS CHILL-CAST & ROLLED & AFTER ANNEALING TO EQUILIBRIUM.

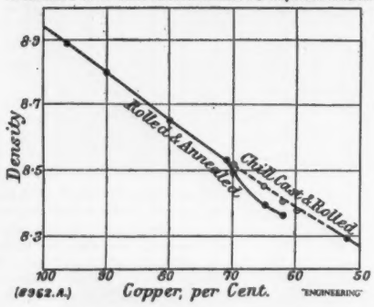
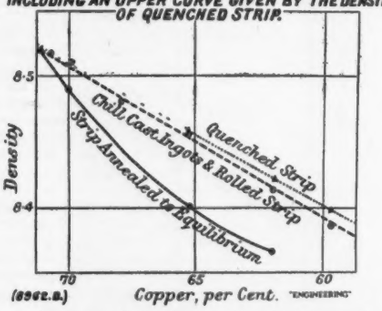


Fig. 2. OPEN SCALE REPRODUCTION OF FIG. 1, INCLUDING AN UPPER CURVE GIVEN BY THE DENSITY OF QUENCHED STRIP.



When heat-treatment had been applied to a cylinder, the surface layer, to a depth of 0·01 in., was turned off before making the density determination.

EXPERIMENTAL WORK.

1. *The Density of the Alloys in Equilibrium.*—As in the work on the α-phase boundary by R. Genders and G. L. Bailey, varying treatments were used to obtain equilibrium conditions in the different alloys. The alloys containing more than 71 per cent. of copper were annealed at 700 deg. C. for 1 hour, and those containing from 70 to 63 per cent. copper at 550 deg. to 500 deg. C. for periods varying from 4 hours to several days. The 59·8 per cent. alloy was annealed at 500 deg. C. for six weeks. The results of density determinations after treatment are given in Table III. Above a copper content of 71 per cent., the density of the alloys is not sensibly changed from that representing the chill-cast condition, and it may be assumed, therefore, that the coring due to rapid cooling through the freezing range is without effect on the net density value. Where the alloys, as originally cast, contained β, the change from the chill-cast state to equilibrium had produced a fall in density, increasing with increase in the proportion of β in the cast alloy to a maximum of 0·06 at a composition of 65 per cent. copper, and tending to decrease again with further decrease of the copper content. The pure β alloy (52 per cent. copper) showed no appreciable change in density, whether quenched in water from 700 deg. C. or slowly cooled to 300 deg. C. at a rate of 10 deg. C. per minute.

The results are given as a curve in Fig. 1. Below 71 per cent. copper, a double curve is shown enclosing a range of variable density, which apparently represents the possible variation in density producible by varying degrees of chill. The point shown at 71 per cent. copper (density, 8·522) was obtained by determinations on a sample of commercial strip.

2. *The Density of the Quenched Alloys.*—The upper curve in Fig. 1, however, does not represent the maximum density possible, since the chilling effect could not be assumed to have suppressed entirely the formation of α after solidification. Specimens of the alloys below 71 per cent. copper were therefore

Fig. 3. DIAGRAM SHOWING EFFECT ON DENSITY OF SUCCESSIVE TREATMENTS GIVEN IN DIFFERENT ORDERS TO THREE SETS OF DUPLICATE SPECIMENS.

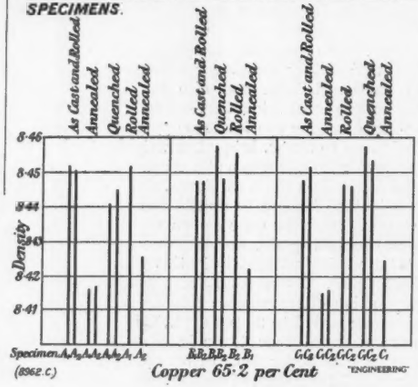


Fig. 4. DIAGRAM SHOWING EFFECT ON DENSITY OF SUCCESSIVE TREATMENTS GIVEN IN DIFFERENT ORDERS TO THREE SETS OF DUPLICATE SPECIMENS.

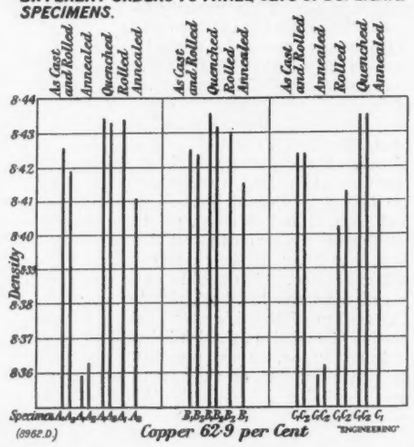


TABLE III.—*Results showing the Density of the Alloys in Equilibrium, and the Reversibility of the Fall in Density brought about by Annealing.*

Copper Content. Per cent.	Density. As Cast and Rolled.	Density after Annealing to Equilibrium.	Density after Quenching from Cast and Rolled Condition.	Quenching Temperature. Deg. C.	Density after Quenching Annealed Material.
99·99	8·933	8·933	—	—	—
96·50	—	8·886	—	—	—
90·00	8·795	8·793	—	—	—
80·20	8·657	8·654	—	—	—
70·00	8·512	8·500	—	—	—
65·20	8·457	8·400	8·456	820	8·453
62·00	8·410	8·368	8·424	820	8·420
59·80	8·382	8·370*	8·397	820	8·398
51·70	8·292	8·294	8·298	700	—

* This specimen was not completely in equilibrium.

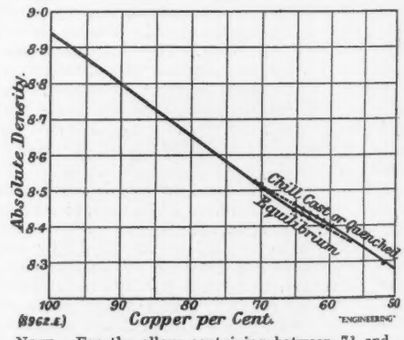
quenched after heating at 820 deg. C. for 45 minutes, and the density determined. The results are given in Table III, and in the open scale curve Fig. 2, extending the variable range above the "chill-cast" curve. A number of specimens, the density of which had been reduced by annealing from the cast and rolled state, were also given the above quenching treatment. The result was a rise in density to about the same value as that obtained by quenching the alloy direct from the original state. These results are included in Table III. In Fig. 2 are also included a number of density determinations on apparently sound portions of chill-cast ingots made in a mould of internal dimensions 12 in. by 6 in. by 1 in. These results are in close agreement with the "chill-cast" curve.

The limiting composition at which β can appear in a chill-cast brass appears to be between 70 and 71 per cent. copper. In order to ascertain whether the curve above a content of 71 per cent. copper could be raised by drastic chilling, a small quantity of molten brass containing 72 per cent. copper was poured into cold water. Micro-examination of the material showed a very small quantity of β, and it was concluded that even under abnormal conditions of casting, the curve as given in Fig. 1 for compositions down to 71 per cent. copper, held good.

There did not appear, however, to be any constitutional reason for the rapid bend of the equilibrium curve below 71 per cent. copper, well within the range of the α phase, and further experiments were carried out with a view to arriving at an explanation of this peculiarity.

3. *Investigation of the Alloys showing a Variable Range of Density.*—Ingots of alloys containing 63 and 64 per cent. copper were cast and rolled as previously described. Duplicate specimens of each were first quenched, and were found to have densities lying on the uppper curve of the variable range (Fig. 2). Annealing of the quenched specimens at 500 deg. C. produced a fall in density, but not sufficiently large to bring the values down to the lower curve (Fig. 2). Specimens of the same ingots, annealed direct from the "as cast and rolled" state, fell in density to positions near the lower curve, some just above and some below. The difference between these positions and the curve, although small, suggested the advisability of further working the specimens to ascertain whether the lack of agreement had been due to local unsoundness. The specimens were accordingly compressed statically to about 33 per cent. of the former length. This treatment gave the unexpected result of increasing the density to a value well above the lower curve and near

Fig. 5. DENSITY OF THE COPPER-ZINC ALLOYS.



NOTE.—For the alloys containing between 71 and 52 per cent. copper two curves are shown, the lower representing the density of the sound alloys in equilibrium, and the upper curve giving the maximum density attainable by chill-casting or quenching.

the "chill-cast" curve. Similar results were obtained by compression of specimens of the 70 and 65·2 per cent. alloys, which had also previously been annealed direct from the cast and rolled state. The results are shown in Table IV, p. 541. It appeared hardly possible that unsoundness of such extent had been present in the original specimens, especially in view of the fact that the fall in density on annealing was reversible in previous specimens by quenching. If unsoundness had been present it would be predicted that, on quenching the compressed specimens, the density would rise to a point above the upper curve of Fig. 2. After applying this treatment, however, the density in each case was found to coincide with the upper curve, no value coming above it.

Specimens of a 61·1 per cent. alloy, prepared as in former cases, gave, after quenching, a further point coinciding with the uppermost curve, and, on annealing at 450 deg. C., the density fell only a small amount to near the "chill-cast" curve. A direct annealing without previous quenching produced, however, a fall in density to a point below the lowest curve. On compression, the value rose to near the "chill-cast" curve, and, on quenching, rose further to a point on the uppermost curve. These results are included in Table IV.

Summarising the above results, it would appear that, on annealing a cast and rolled alloy containing β, the fall in density consequent to the change from β to α is accompanied by an added fall which can be largely neutralised by compression, and may, therefore,

be assumed to be due to the formation of cavities. At the same time, the fact that quenching the annealed alloy can reverse the whole of the fall, suggests that the unsoundness is produced as a consequence of the constitutional change during annealing, and does not consist of cavities such as exist in a casting. One of the chief points arising from the results is that the lowest curve does not represent the crystal density of the alloys in equilibrium, as would be concluded from the first series of results, but a value lower than the true one. The probable true value is represented by the density given on compression after annealing to equilibrium.

Investigation of the peculiar effect described above was made, using two new alloys, containing 65·2 and 62·9 per cent. copper, respectively, cast in the 9 in. by $\frac{1}{2}$ in. by 1 in. mould and rolled in the usual manner. In the place of cylinders, rectangular specimens 1 in. by 0·9 in. by 0·5 in. were prepared from the slabs, with the object of avoiding the possible unsatisfactory features of compression by substituting rolling treatment for the closing of the cavities. Three sets of duplicate specimens of each alloy were given successive treatments similar to those in the previous series, but in different orders. The density was determined at each stage of the treatments. Specimens A_1 and A_2 were annealed to equilibrium at 500 deg. C., and then quenched from 820 deg. C.; A_1 was re-annealed to equilibrium at 500 deg. C., and A_2 was rolled to a reduction of 50 per cent. in thickness. Specimens B_1 and B_2 were quenched from 820 deg. C.; B_1 was annealed and B_2 rolled to 50 per cent. reduction. Specimens C_1 and C_2 were annealed, then rolled to 50 per cent. reduction and afterwards quenched; C_1 was then annealed.

The results, shown graphically in Figs. 3 and 4, substantially confirm the previous experiments, and lend support to the theory formed regarding the phenomenon of the production of unsoundness by constitutional change. They provide, also, confirmation of the previous values from annealed and compressed cylinders, and enable the curve for the crystal density of the alloys in equilibrium to be fixed. The final curve representing the crystal density of the whole range of alloys, and including the upper curve representing the density of quenched alloys in the variable range, is given on an open scale in Fig 5. The portion of the curve concerning alloys which show a variable density range possesses no features incompatible with the constitutional diagram, providing a smooth continuation of the portion relating to the more copper-rich alloys. The curve representing equilibrium conditions lies a small, but distinctly measurable, distance below the curve for the chilled or quenched alloys, and, since alloys containing between 61 and 62 per cent. copper can be obtained either as all α or all β, gives over that range the net volume change produced by change from the cube-centred lattice of β to the face-centred lattice of α the same composition. By calculating from the formulæ given by Owen and Preston, values for the parameter of α and β can be arrived at. These values, for compositions of 61 and 62 per cent. copper, are given in Table V.

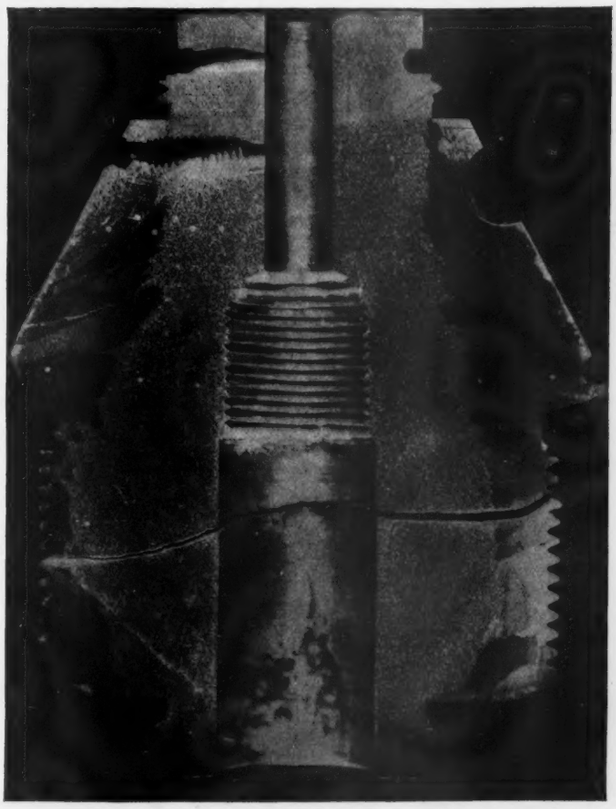


FIG. 6. QUENCHED FUSE BODY CONTAINING 57·2 PER CENT. COPPER, WHICH CRACKED AFTER MACHINING.

TABLE IV.—*Effect of Compression in Raising the Density of Specimens Annealed from the Cast and Rolled State.*

Copper Content. Per cent.	Original Condition of Alloy.	Density in Original Condition.	Density after Annealing.	Density after Compression of Annealed Cylinders.	Density after Re-quenching Compressed Cylinders.
70·0	Cast and rolled	8·512	8·495	8·508	—
65·2	Cast and rolled	8·456	8·396	8·445	8·460
64·0	Cast and rolled	—	8·362	8·432	8·436
64·0	Quenched	8·448	8·429	—	—
63·2	Cast and rolled	—	8·361	8·422	8·433
63·2	Quenched	8·431	8·425	—	—
61·1	Cast and rolled	—	8·366	8·384	—
61·1	Quenched	8·416	8·400	8·399	8·414

TABLE V.—*Values for the Parameter of α and β.*

Copper. Per cent.	α.			β.		
	Density.	Calculated Cube Edge Å.	X-ray Measurement.	Density.	Calculated Cube Edge Å.	X-ray Measurement. (extrapolated).
62·0	8·410	3·694	3·696	8·424	2·930	2·928
61·1	8·400	3·696	3·698	8·416	2·932	2·930

The parameter values calculated from the author's density results agree closely with the average X-ray measurements of Owen and Preston. It may be pointed out, however, that the agreement in duplicate determinations of density is much closer than that yet obtainable in X-ray measurements of crystal lattice.

Conclusions.—Values have been obtained for the crystal density of the brasses in equilibrium over the range of composition used industrially. The effect of coring in α brasses on the net density appears to be negligible; the alloys which contain β in the chill-cast state, however, have a small range of variable density due to the difference in density between α and β, and the density of sound castings may vary according to the amount of β produced by the particular conditions under which the alloy was cooled from the liquid state to temperatures within the region of 450 deg. C.

An alloy always consisting entirely of β, is unaffected in density by heat-treatment, and it is apparent that whatever the nature of the transformation at 470 deg. C., either there is no accompanying volume change, or the transformation is not suppressed by any ordinary method of quenching.

The differences which have been observed by Bamford and other workers between the densities of sand- and chill-castings are considered to be due to the presence in the sand-castings of fine porosity consisting of interdendrital cavities. During the slow cooling of an alloy through a "pasty range," the growth of primary dendrites probably leads to the entrapping of small volumes of liquid which on solidification leave cavities. In chill-casting, solidification is more directional, and the cavities tend to be concentrated away from the cooling surfaces.

A phenomenon not previously observed by the authors in any alloy, consisting in a reduction of density due to unsoundness accompanying constitutional change (β to α), has been found to occur in the brasses over a considerable range of composition. The unsoundness produced is removable, either by reversing the constitutional change (as by quenching) or by mechanical compression. Although only a relatively small range of density is affected by the changes observed, the close agreement among large numbers of results from several alloys leaves no doubt that the effect is real. The conclusion is reached that such "unsoundness" cannot be of the visible type, but that the cavities may be of atomic dimensions. It is possible that they are formed at the boundaries of inclusions, or other metallic discontinuities, where alteration in crystal structure might conceivably affect contact. The possibility of the effect being due to gases has also been considered. It is not proposed, however, pending the results of further work, to advance an explanation at present.

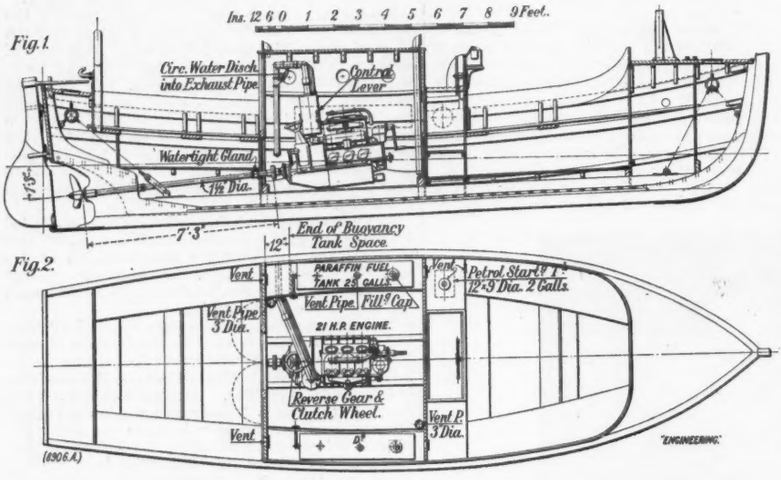
From a practical point of view, it is of particular interest that heat-treatments, involving quenching of the α–β brasses and a small range of the α brasses, may give rise to internal stresses of considerable magnitude, consequent on constitutional changes taking place during quenching. The cracking of heat-treated articles which sometimes occurs, appears to be attributable to constitutional volume change rather than to the difference between the expansivities of the different constituents.

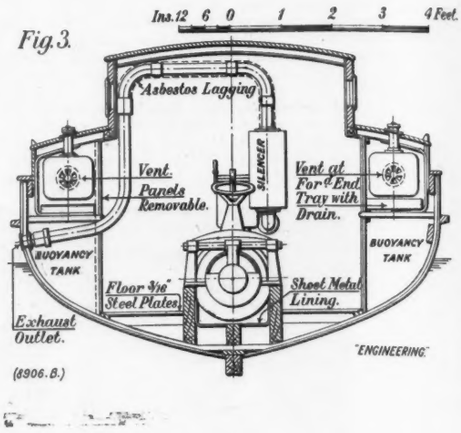
A striking example of the type of failure which may occur is illustrated by the fuse-body shown in Fig. 6, which cracked after machining. The brass contained 57·2 per cent. copper. Although the history of the specimen is unknown, a quenching treatment had evidently been applied. In the outer region, the rate of cooling had been sufficiently rapid to retain a structure consisting entirely of the β solid solution. Owing to the considerable mass of the article, the inner region had cooled at an appreciably slower rate, allowing the formation of a quantity of the α solution accompanied by an expansion in volume. It is concluded that the resulting internal stresses were the primary cause of the failure. Instances such as this point to the desirability of employing a low-temperature heat-treatment for the removal of stress, subsequent to the quenching operation.

FARADAY HOUSE SCHOLARSHIPS.—As a result of the Entrance Scholarships Examination, held at Faraday House Electrical Engineering College recently, the "Faraday" Scholarship of 50 guineas per annum, tenable for two years in college and one year in works, has been awarded to Mr. R. J. Hiller, of Taunton School. Mr. M. S. Hawker, of Radley College, secured the "Maxwell" Scholarship of 50 guineas per annum, tenable for one year at college and one year in works, while Mr. R. P. Horlock, of Erith County School, and Mr. E. J. R. Kay, of Aldenham School, gained Exhibitions of thirty guineas per annum, tenable for one year in college and one year in works. An Exhibition of 20 guineas, tenable for one year in college and one year in works, was won by Mr. R. B. Barton, of Lancing College, the final award, an entrance prize of 20 guineas, going to Mr. J. E. W. Ginger, of Watford Grammar School.

MOTOR LIFEBOAT FOR THE CUNARD STEAMSHIP COMPANY.

CONSTRUCTED BY THE DESPATCH MOTOR AND LIFEBOAT COMPANY, SOUTHAMPTON.





MOTOR LIFEBOAT FOR PASSENGER STEAMERS.

ALTHOUGH some of our foremost shipping companies have already equipped their large passenger vessels with motor lifeboats capable of towing, in the event of a disaster, a number of ordinary lifeboats, this provision has so far been a purely voluntary one. The Board of Trade Statutory Rules and Orders of 1924 relating to life-saving appliances, which come into force on July 1 of this year, however, make it compulsory, in the case of vessels carrying more than 15 lifeboats, that one shall be a motor-boat, and, if more than 20 boats are carried, two shall be motor-boats; the motor-boats in all cases must be fitted with approved wireless-telegraphic installations and with searchlights.

A standard motor lifeboat to comply with these requirements and ordered from the Parsons Motor Co., Limited, Town Quay Works, Southampton, by the Cunard Steamship Company, is illustrated in Figs. 1 to 4 herewith, while in Figs. 5, 6 and 7, on page 543, are given a longitudinal section, a transverse section, and a general view, respectively, of the engine with which the boat is equipped. The boat, which was built for the Parsons Motor Company by the Despatch Motor and Lifeboat Company, of Southampton, is 28 ft. in length, 8 ft. 6 in. in beam, 3 ft. 6 in. in depth, and has a draught of approximately 2 ft. She is carvel built of teak planking $\frac{7}{8}$ in. in thickness, the keel, stem and stern posts, deadwoods, floors, knees and deck beams all being of English oak, while the decking, benches, thwarts, portable seats and bulkheads are of Oregon or Columbian pine. The engine bearers, floor carlins and bottom boards are of red pine. The general arrangement of the boat can be followed from Figs. 1, 2 and 3, and her appearance at sea is well shown in Fig. 4. A chain locker, it will be seen, is provided right forward, this being fitted with the usual chain pipe and fixings, while a suitable length of chain and one anchor are provided as required by the Board of Trade. An 8-in. coir fender is fitted all round the boat under the main rubbing piece, and 1¼-in. Manila lifelines are also provided. The exterior is finished in the usual manner for this class of boat, the decks, covering boards, bulkheads, &c., being varnished.

The wireless equipment, which consists of a 250-watt Siemens quenched-spark set having a 50-mile transmission range, is supplied with high-tension current from a motor generator operated by a battery of accumulators; the latter are kept charged from the ship's mains. The apparatus, including a valve receiving set, is accommodated immediately aft of the chain locker in a small cabin which gives the operator sufficient room to carry out his duties. One mast for supporting the wireless aerial is mounted, as shown in Fig. 4, immediately over the operator's cabin, the other being stepped at the aft end of the after cockpit. The masts are each 22 ft. in length and are spaced 22 ft. apart. When lowered, the forward mast is supported by a bolt at the top of the tabernacle, the foot of the mast projecting forward, but the after mast cannot be accommodated in this way owing to the fact that the foot would foul the after sling hook; it has therefore to be moved and secured by the lower bolt. When stowed, the masts lie side by side and do not project beyond the ends of the boat.

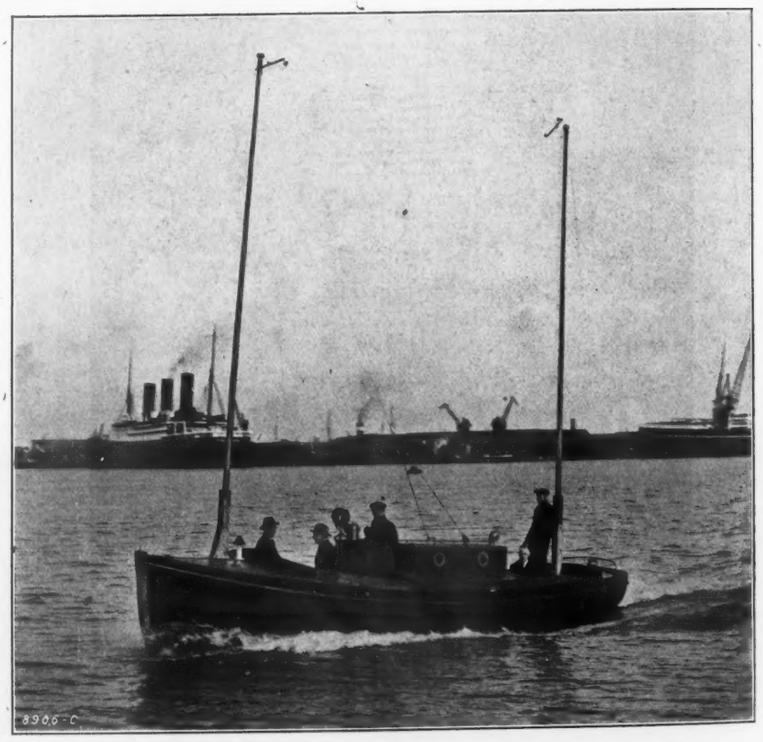


FIG. 4.

Seating accommodation for passengers is provided in a well forward, between the wireless cabin and engine cabin, and stowage space is available under the seats for the usual equipment of biscuits, water, condensed milk, &c. Aft of the engine cabin, another well provides additional passenger accommodation. The steersman is located in a raised position immediately forward of the engine cabin, where he is well protected from the weather while having a clear view over the heads of the passengers in the forward well. A speaking tube provides communication between the steering position and the engine cabin. The latter is located amidships and has sufficient headroom to enable the engineer to remain inside. It is lighted by small portholes on each side and at the forward end. Ventilation is maintained by cowls at the forward and after ends, as shown in Figs. 1 and 4, so that the doors in the after end can be kept closed in bad weather, thus preventing the possibility of the engine being put out of action by sea water.

The propelling machinery, illustrated in Figs. 5 to 7 opposite, consists of a standard 21-h.p., three-cylinder Parsons engine, starting on petrol and running on paraffin; its normal speed is from 850 r.p.m. to 900 r.p.m. The cylinders, which are of 4½ in. bore, with a piston stroke of 6 in., are amply water jacketed, and provision is made for cleaning out the jackets, as can be seen in Fig. 5. The connecting rods are of H-section, drop forged from steel and fitted with die-cast white-metal big-end bearings. The crankshaft is a solid steel forging, machined all over and supported in bearings on both sides of each crank, the bearings being also of die-cast white-metal. A flywheel forming one part of a cone clutch is fitted at the after end, the other part of the clutch being connected to the epicyclic reverse gear, as shown in Fig. 5. The reverse gear, which is enclosed in an extension of the crank-case casting so as to form a single unit with the engine, is controlled by screw gear operated by a single hand wheel. A length of manganese-bronze shafting connects the reverse gear to the propeller. The whole of the controls are mounted on the engine itself and

21-B.H.P. THREE-CYLINDER PARAFFIN ENGINE FOR MOTOR LIFEBOAT.

CONSTRUCTED BY THE PARSONS MOTOR COMPANY, LIMITED, ENGINEERS, SOUTHAMPTON.

Fig. 5.

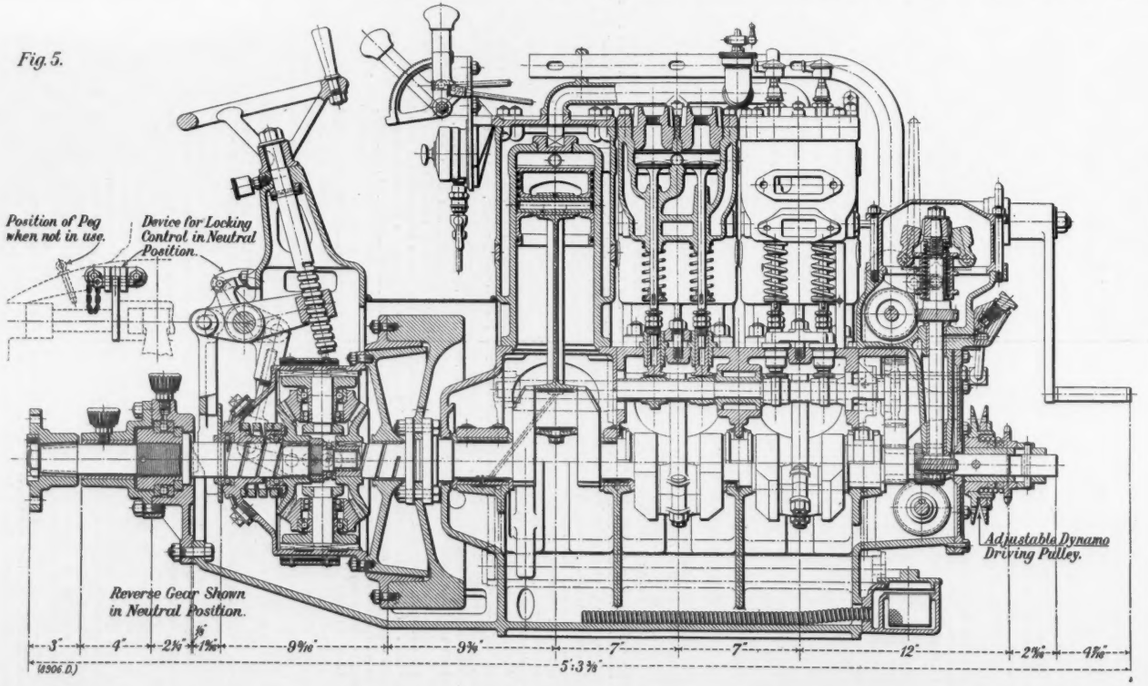
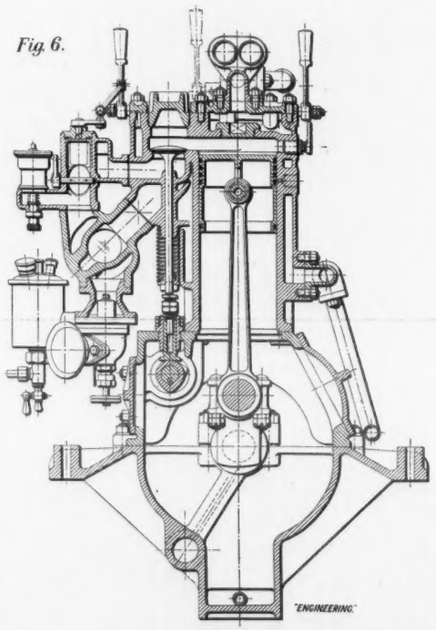


Fig. 6.



conveniently situated for the engineer. Forced lubrication is provided and magneto ignition is normally employed, although battery and coil ignition is available as a standby. The magneto is fitted with an impulse starter. Figs. 1, 2 and 3 show the arrangement of the silencer and exhaust piping, and it will be seen that there is no possibility of the latter causing trouble from heating the floor boarding or seats. Water from the circulating system, after passing round the silencer, is led into the descending portion of the exhaust pipe and thus discharges overboard with the gases.

Fuel tanks of 25 gallons capacity are located on each side of the engine cabin, as shown in Figs. 2 and 3, and a separate tank, holding 2 gallons of petrol for starting the engine, is placed on the port side of the steering position. The fuel tanks are constructed of lead-coated steel, and their capacity is sufficient to enable the boat to travel a distance of over 100 miles at the regulation speed. Trays draining overboard are placed under all the tanks, so that there is no possibility of oil or petrol collecting in the boat itself. As shown in Fig. 3, the filling fittings are brought up through the deck, and "save-alls" are provided to prevent the decking from becoming saturated with any oil or petrol which may be spilled in the course of filling the tanks. Buoyancy tanks, to the full requirements of the Board of Trade, are fitted under the side seats of the boat and on each side of the engine cabin, as shown in Fig. 3.

Trials of the boat were carried out on Southampton Water some time ago, a speed of about 7½ knots being attained and the manœuvring qualities proving quite satisfactory. The wireless installation was also tested successfully.

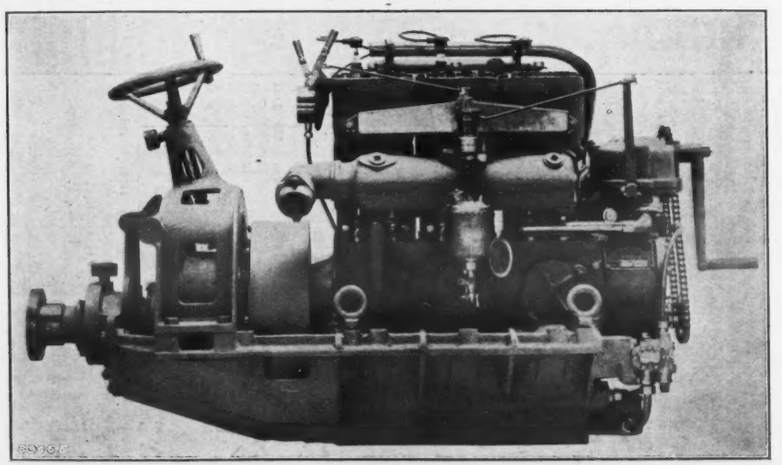


FIG. 7.

THE INSTITUTION OF CIVIL ENGINEERS.—The Council of the Institution of Civil Engineers have made the following awards in respect of Papers read and discussed at the ordinary meetings during the Session 1924-1925:—A Telford Gold Medal to Mr. Donald Paterson; a Watt Gold Medal to Dr. E. H. Salmon; a George Stephenson Gold Medal to Mr. L. H. Savile, C.B.; Telford Premiums to Mr. G. Mitchell, Dr. T. E. Stanton, C.B.E., F.R.S., and Mr. F. E. Wentworth-Sheilds, O.B.E.; a Crampton Prize to Professor A. H. Gibson, D.Sc., and a Manby Premium to Mr. P. W. Robson, O.B.E.

LOCOMOTIVE INTERCHANGE.—In order to provide the technical staffs of the Great Western and London and North Eastern Railway Companies with data regarding the performance of each other's passenger express locomotives, trials have been undertaken during the past week on these railway systems. In each case the engine was manned by its own crew. A G.W.R. locomotive of the Caerphilly Castle class was attached every alternate day to the Flying Scotsman express leaving King's Cross each morning at 10 a.m., while a L.N.E.R. engine, of the Pacific type, pulled the Cornish Riviera express, which leaves Paddington for Penzance at 10.30 a.m. daily. The results of these tests will be awaited with interest, and it is to be hoped that the results will be made public in due course.

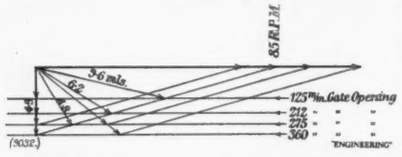
LETTERS TO THE EDITOR.

HYDRO-ELECTRIC PLANT AT FORSHUVUDFORSEN, SWEDEN.

TO THE EDITOR OF ENGINEERING.

SIR,—In reply to the observations made by Professor Gibson in your issue of February 27, I beg to make the following remarks in my capacity as mechanical engineer on the staff of the consulting engineers, "Vattenbyggnadsbyrån," who designed the whole installation.

The readings were taken from an uncontrolled vacuum-gauge and from a gauging-rod, measuring the depth of the water-level in a small vessel communicating through a narrow pipe with the draught-tube opening. Heavy surges and local excess or deficiency of pressure in the draught-tube changing with the gate-opening, introduced errors which must be considerable in relation to the small difference measured. Thus the



accuracy of the measurement must not be overrated. The variations of different readings with the speed of the turbine gives a certain idea thereof.

The investigations made afterwards were intended to show that no unusual losses, due, for instance, to the shortness of the draught-tube, the design of which did not agree fully with the intentions of the turbine makers, reduced the efficiency of the turbine.

However, if the regain of head, according to the diagram, be regarded as a function of the velocity of the water leaving the runner instead of as a function of its normal component, the diagram is put in a less discordant light. At the time I worked out the following table, based on the above very rough diagram:—

Test number	1	2	3	4
Gate opening .. .. mm.	125	212	275	360
Speed .. .. .. r.p.m.	83·3	83·3	83·3	83·3
Vacuum reading .. m.	4·67	4·70	4·57	4·21
Head .. .. .. m.	+138·18	138·15	138·25	138·64
Tail water .. .. m.	+138·99	138·98	139·14	139·08
Regain of head .. .. m.	0·81	0·83	0·89	0·44
Discharge .. .. m^3/s	30·6	46·4	58·4	67·9
Velocity of water—				
Normal component (c) m/s	2·23	3·37	4·18	4·88
Full .. .. (v) m/s	9·6	6·2	4·8	4·9
$\frac{c^2}{2g}$	0·26	0·58	0·89	1·21
$\frac{v^2}{2g}$	4·7	1·97	1·18	1·21
Efficiency of draught-tube related to—				
$\frac{c^2}{2g}$	3·10	1·43	1·00	0·37
$\frac{v^2}{2g}$	0·17	0·43	0·76	0·37

I emphasise once more the essentially relative meaning of these figures.

Yours faithfully,
KARL T. KULSSON.

Stockholm, April 16, 1925.

DISTANT-READING TANK GAUGE.

TO THE EDITOR OF ENGINEERING.

SIR,—A gauge for indicating, at a distance, the depth of liquid in a tank similar to that described in ENGINEERING of January 30, page 150, was installed by me in our factory two years ago, and has been working since without stopping. It is based on the same principle as that of Messrs. Negretti and Zambra, and is fed with air from a pneumatic bag through a very small hole in the diaphragm placed in the ordinary valve.

The only difference between the gauge of Messrs. Negretti and Zambra and mine consists in this: instead of a gauge with a dial, I use simply a U-shaped tube of glass, filled with the same liquid as that in the tank. This arrangement has the advantage of simplicity and gives quite satisfactory results. The scale of the instrument can be easily divided experimentally to read as desired in weight or volume, quite independently of the influence of the shape of the tank, and therefore can be adapted to every tank, whatever its form may be.

There is no need to remark that the instrument with tube shows the actual depth of the liquid, reduced to the temperature of the room where the instrument is placed.

Yours faithfully,
ENGINEER W. SOKOLOW.

Moscow. Automobilfactory Amo, Simonova, Slobodka, April 19, 1925.

BOOKS RECEIVED.

United States Geological Survey. Water Supply Paper No. 513. *Surface Water Supply of the United States*, 1919-1920. Part XII. *North Pacific Slope Drainage Basins. (B) Snake River Basin.* [Price 30 cents.] No. 519. *Ground Water in Santa Clara Valley, California.* By W. O. CLARK. [Price 35 cents.] No. 520—D. *Base Exchange in Ground Water by Silicates as Illustrated in Montana.* By B. C. RENICK. No. 520—E. *The Artesian Water Supply of the Dakota Sandstone in North Dakota. With Special Reference to the Edgeley Quadrangle.* By O. E. MEINZER and H. A. HARD. No. 525. *Surface Water Supply of the United States*, 1921. Part V. *Hudson Bay and Upper Mississippi River Basins.* [Price 20 cents.] No. 532. 1921. Part XII. *North Pacific Slope Drainage Basins (A) Pacific Basins in Washington and Upper Colombia River Basins.* [Price 25 cents.] No. 538. *The San Juan Canyon, South Eastern Utah. A Geographic and Hydrographic Reconnaissance.* By H. D. MISER. [Price 30 cents.] No. 560—A. *Water Power and Irrigation in the Madison River Basin, Montana.* By J. F. DEEDS and W. N. WHITE. Washington: Government Printing Office.

The Cochran Book of Oil Firing. By W. K. WILSON, B.Sc., Wh. Ex. Annan: Cochran and Co. (Annan), Limited. [Price 4*s.* 6*d.* net.]

Air Ministry. Meteorological Office. Particulars of Meteorological Reports Issued by Wireless Telegraphy in Great Britain and the Countries of Europe and North Africa. London: His Majesty's Stationery Office. [Price 3*s.* 6*d.* net.]

The Sweden Year Book, 1925. Stockholm: Almqvist and Wiksells Boktryckeri A.B.

United States Bureau of Mines. Technical Paper No. 374. *Accidents at Metallurgical Works in the United States*, 1923. By W. W. ADAMS. [Price 5 cents.] Bulletin No. 190. *Coal Mining Problems in the State of Washington.* By G. W. EVANS. [Price 20 cents.] No. 246. *Quarry Accidents in the United States*, 1923. By W. W. ADAMS. [Price 15 cents.] Washington: Government Printing Office.

House Heating. By MARGARET FISHENDEN, D.Sc., F.Inst.P. London: H. F. and G. Witherby. [Price 25*s.* net.]

Profitable Science in Industry. By DWIGHT T. FARNHAM, and others. New York: The Macmillan Company. London: Macmillan and Co, Limited. [Price 15*s.* net.]

United States Geological Survey. Mineral Resources of the United States. I: 17. *Antimony in* 1923. By F. C. SCHRADER. I: 18. *Iron Ore, Pig Iron and Steel in* 1923. By E. F. BURCHARD and H. W. DAVIS. II: 20. *Potash in* 1923. By G. R. MANSFIELD and L. BOARDMAN. II: 21. *Stone in* 1923. By G. F. LOUGHLIN and A. T. COONS. II: 23. *Phosphate Rock in* 1923. By G. R. MANSFIELD. II: 24. *Lime in* 1923. By G. F. LOUGHLIN and A. T. COONS. II: 25. *Feldspar in* 1923. By J. MIDDLETON. II: 27. *Abrasive Materials in* 1923. By F. J. KATZ. Washington: Government Printing Office.

PERSONAL.—The firm previously known as Frank How and Co., manufacturers and blenders of "Trogon" oils, of Trogon Wharf, Stratford, London, E. 15, has now been transformed into a private limited liability company trading under the name of Frank How and Co., Limited. Mr. H. M. Heasman is associated as sales director with Mr. R. Loxley How, the principal partner.—Messrs. Delco-Remy and Hyatt, Limited, engineers, of 58, Victoria-street, London, S.W. 1, are now conducting business from their recently acquired offices and works at 111, Grosvenor-road, S.W. 1.—The firm of John A. Smeeton, Limited, of 15, Victoria-street, Westminster, London, S.W. 1, have been appointed sole agents for the Demag Company for all rolling mill and other similar plant. Mr. T. Fearnley Allen, of 67, Norwich Union Chambers, Birmingham, has been appointed agent for the Midland area by the former company.

CONTRACTS.—Messrs. Howden Ljungström Preheaters (Land), Limited, of 133, Helen-street, Govan, Glasgow, have received an order to supply one preheater, having a heating area of 21,500 sq. ft., to Messrs. Ransome and Marles Bearing Company, Limited, at Newark-on-Trent.—Messrs. Stothert and Pitt, Limited, of Bath, have received an order for 27 electric jib cranes of their latest crank-operated, horizontal, luffing type; 19 of these will have a lifting capacity of 3 tons at 74 ft. 9 in., or 1½ tons at 85 ft. 9 in. radius, and the other eight cranes will deal with 1 ton at 48 ft. 6 in. radius. The 27 cranes, together with the 31 now being built by the firm, will form the complete crane equipment for the new Gladstone Dock.—Messrs. Alfred Herbert, Limited, of Coventry, have received a further order from the Amsterdam Electricity authorities for the supply of four large Atritor unit pulverisers, each capable of treating 6,000 lb. of bituminous coal per hour. These machines will fire a Clayton water-tube boiler having a normal evaporation of 154,000 lb. of water per hour.—The British Separators, Limited, of 14, Queen Victoria-street, London, E.C. 4, have secured a contract for the supply of "Vickeen" oil purifiers for treating both fuel and lubricating oils for the main Diesel engines of the oil-tank vessel being constructed by the Fairfield Shipbuilding and Engineering Company, Limited, of Govan, for Messrs. Houlder Brothers.—*Erratum.* In the reference to the order for four boilers for the Thames Board Mills, Limited, Purfleet, secured by the Vickers Spearing Boiler Company, Limited, of 20, Kingsway, London, W.C.2, given in our issue of April 17, on page 480, the combined normal evaporation of these boilers should have read 200,000 lb., instead of 100,000 lb., of water per hour.

NOTES FROM SOUTH YORKSHIRE.

SHEFFIELD, Wednesday.

Iron and Steel.—The position shows some improvement as compared with a week ago, due to the re-starting of heavy steel plant. General conditions, however, are far from satisfactory. The most favoured sections of local manufacture are not working at more than two-thirds capacity, and the prevailing burden of costs is accentuated by the expense of upkeep of plant that is only intermittently engaged. There are still 20,000 operatives in Sheffield alone for whom no work can be found. Lack of confidence in the finished branches reflects adversely upon the market for raw and semi-finished materials. Users of steel billets are disinclined to book far ahead, and would be assisted in meeting the demands of their customers if prices were reduced to a level comparable with those quoted by foreign steel-makers, but producers in South Yorkshire feel they cannot offer more attractive rates without prejudicing their position. Crucible steel is having to meet exceptionally keen competition from Continental makers offering special terms of payment. Much of this foreign material is of good quality and is priced at something like half the local cost. One of the chief hindrances to arriving at more attractive rates in this district is the present price of melting coke, which represents an increase per ton of over 80 per cent., three tons of such fuel being required to make one ton of steel. The file trade is making slow headway in face of considerable difficulty. Orders fall thirty per cent. below the level of production capacity. The prohibitive tariff obtaining in the United States not only excludes local makers from the biggest file market in the world, but allows American manufacturers more scope to compete in less remunerative markets, and, in particular, in British Colonies. Agricultural steel and castings appear to be an improving section, and there is an active call for garden tools, builder's ironware, magnets, and automobile fittings.

South-Yorkshire Coal Trade.—Business shows a certain measure of revival now the holiday influence has been removed, but the number of inquiries in circulation is disappointing, and there is keen competition for orders. Steam coal for export has taken on a somewhat firmer tone. Inland sales are maintained at a steady level at unchanged rates. The position in cobbles, nuts and slacks is mainly unchanged, supplies being more than ample to meet requirements. Smalls have declined an average of ninepence per ton. The demand for best housecoal shows an improvement on last week. Supplies of inferior grades are still abundant, despite restricted production. Quotations: Best branch handpicked, 30*s.* to 33*s.*; Barnsley best Silkstone, 26*s.* to 27*s*; Derbyshire best brights, 26*s.* 6*d.* to 29*s.* 6*d.*; Derbyshire best house, 24*s.* to 26*s.*; Derbyshire best large nuts, 20*s.* to 24*s.*; Derbyshire best small nuts, 14*s.* to 16*s.*; Yorkshire harda, 18*s.* to 22*s.*; Derbyshire hards, 18*s.* 6*d.* to 22*s.*; Rough slacks, 10*s.* to 12*s.* 6*d.*; Nutty slacks, 8*s.* 6*d.* to 10*s.*; Smalls, 3*s.* 6*d.* to 5*s.* 6*d.*

LIGHTING FOR TRAFFIC CONTROL.—In order to assist in the traffic control of one of the main roads in Leicester, the Superintendent of Public Lighting, Mr. Thos. Wilkie, acting on the instructions of the Lighting Committee, is erecting a spot lighting apparatus. The light will be mounted on a pole 30 ft. high, and the beam focussed on the pointsman on duty. It is hoped by this means to make the pointsman's signals clear to drivers of vehicles and to pedestrians. This is stated to be the first equipment of the kind to be used in Great Britain.

ROYAL AIR FORCE DISPLAY.—The Air Ministry announces that the Royal Air Force Pageant, which was instituted in 1920, has now been renamed the Royal Air Force Display, and will take place on June 27, at the London Aerodrome, Hendon. H.M. The King, Chief of the Royal Air Force, hopes to be able to attend. A programme has been arranged which will introduce new features enabling the developments constantly taking place in the aerial arm to be appreciated. As in the case of the Royal Tournament, all the proceeds will be devoted to Service charities.

TENDERS.—It is announced by the Department of Overseas Trade, of 35, Old Queen-street, London, S.W. 1, that the Government of the Province of Buenos Aires have approved the estimates prepared by the Department of Sanitary Works for water and sewage-disposal works at San Fernando, to cost 659,300*l.*; at San Isidro, to cost 918,591*l.*; and at Vicente Lopez, Olivos, Bartolome Mitre and Florida, to cost 960,211*l.*—Tenders are invited, until June 10, by the State Electricity Works at Montevideo, Uruguay, for the supply of six aerial transformer sub-stations mounted on tubular or reinforced concrete columns.—The Egyptian Ministry of Public Works invites tenders, in Egyptian currency, until July 1, 1925, for the supply of pumping plant and motors for equipping a floating dock.—The Department of Public Works of New South Wales will receive tenders, to be presented in Sydney by June 29, for the supply and erection of pumping machinery, ironwork, a crane and gantries, &c., for the Dubbo water-supply scheme.—A Vancouver firm desires to get into touch with United Kingdom suppliers of boilers and hot-water heating equipment for residences, and low-pressure steam-heating apparatus for houses and business premises, for the purpose of receiving tenders.—The Municipality of Pretoria, South Africa, invite tenders, until May 4, for the supply of a portable petrol-driven sewage-pumping plant. All inquiries regarding these calls for tenders should be made to the Department of Overseas Trade.

NOTES FROM CLEVELAND AND THE NORTHERN COUNTIES.

MIDDLESBROUGH, Wednesday.

The Cleveland Iron Trade.—Though Cleveland pig-iron is far from plentiful, values are by no means strong. Sellers are keen to negotiate and customers are backward. The latter report that they can satisfy their requirements at below recognised market quotations, but business is largely confined to transactions in small lots to meet early needs. There has been rather more business with Scotland, and inquiries on Continental account show some slight improvement, but actual overseas sales are trifling. No. 1 is 82*s.*; No. 3 g.m.b., 77*s.*; No. 4 foundry, 76*s.*; and No. 4 forge, 75*s.*

Hematite.—East-Coast hematite is abundant, makers' stocks being heavy. Curtailment of output by the suspension of operations at the two blast furnaces at the Thornaby Ironworks of Messrs. Whitwell and Co. has not strengthened the market at all. Home customers are acting with caution, and export buyers are placing few orders. Nos. 1, 2, and 3 are on sale at 82*s.*; and No. 1 is quoted 82*s.* 6*d.*

Foreign Ore.—Imported ore is almost unsaleable. Market quotations remain nominal on the basis of best rubio at 22*s.* c.i.f. Tees.

Blast-furnace Coke.—Durham blast-furnace coke is in only moderate request. Good average qualities are offered at 22*s.* 6*d.* delivered to local consumers' works.

Manufactured Iron and Steel.—Whilst sales of manufactured iron and steel continue difficult to arrange, the general situation is regarded as somewhat less unsatisfactory than it has been. Continental competition is not quite so keen, but overseas inquiries are on a scale vastly below what could be desired. Among the principal market quotations are :—Common iron bars, 11*l.* 12*s.* 6*d.*; iron rivets, 14*l.* 5*s.*; packing (parallel), 8*l.*; packing (tapered), 11*l.* 10*s.*; steel billets (soft), 8*l.* 5*s.*; steel billets (medium), 9*l.*; steel billets (hard), 9*l.* 10*s.*; steel boiler plates, 12*l.* 10*s.* to 13*l.*; steel ship, bridge and tank plates, 8*l.* 17*s.* 6*d.*; steel angles, 8*l.* 10*s.*; steel joists, 8*l.* 10*s.*; heavy steel rails, 8*l.* 10*s.*; black sheets (24-in. gauge), 11*l.* 10*s.*; and galvanised corrugated sheets (24-in. gauge), 16*l.* 15*s.*

NOTES FROM THE NORTH.

GLASGOW, Wednesday.

Scottish Steel Trade.—The position in the Scottish steel trade has not eased at all up to the present, and a general dullness still prevails, but a more hopeful feeling is noticeable. Little response has been made by buyers to the recent lower quotations, and, in many instances, it would seem as if buyers were in no hurry to place fresh business meantime. Bookings have not come up to expectations and there is a dearth of specifications at the different works. Inquiries, while better, are developing very slowly and the conditions show little improvement. There is a fair outlet for constructional material, but steel for shipbuilding purposes moves only slowly. The works on black sheets are turning out quite a respectable tonnage, and order books are fairly well filled. Galvanised sheets continue in quite good demand, with export orders perhaps just a shade easier. Boiler plates are unchanged in price, but ship plates and sections are lower by 5*s.* and 7*s.* 6*d.* per ton, respectively. The following may be taken as the current quotations :—Boiler plates, 12*l.* 10*s.* per ton; ship plates, 9*l.* per ton; sections, 8*l.* 7*s.* 6*d.* per ton; and sheets, ⅜ to ½ in., 10*l.* 12*s.* 6*d.* per ton, all delivered Glasgow stations. While these must be taken as the general standard of prices, favourable lines could almost certainly be done at lower rates.

Malleable-Iron Trade.—There has been little movement in the malleable-iron trade of the West of Scotland over the week and a poor demand is reported. The day-to-day output is of small proportions, and it is with difficulty that the works are being carried on. In the steel re-rolling branches, business is not too plentiful, but, nevertheless, quite a fair amount is in hand. Prices are unchanged, with "Crown" bars at 11*l.* 12*s.* 6*d.* per ton, delivered Glasgow.

Scottish Pig-Iron Trade.—The demand now being experienced by the Scottish pig-iron makers is far from satisfactory, and stocks are increasing. Sales are difficult to effect, as inquiries are limited and the tonnage asked for, in most cases, is very small. An improvement is looked for in the demand from the steel works for hematite iron, but so far the freedom of action which the steelmakers now possess with regard to prices has failed to bring out much more business. Foundry grades are in poor request at present, and prices are a turn easier. The current quotations are as follow :—Hematite, 4*l.* 10*s.* 6*d.* per ton, delivered at the steel works; foundry iron, No 1, 4*l.* 10*s.* per ton, and No. 3, 4*l.* 7*s.* 6*d.* per ton, both on trucks at makers' yards.

Scottish Pig-Iron Shipments.—The shipments of Scottish pig-iron from Glasgow Harbour, for the week ended last Saturday, April 25, amounted to 1,480 tons. Of that total 1,338 tons went overseas and 142 tons coastwise. For the corresponding week of last year, the figures were 956 tons foreign and 103 tons coastwise, making a total shipment of 1,059 tons.

Scottish Pig-Iron Trade Wages Reduced.—Messrs. Kerr, MacLeod and Macfarlan, Glasgow, have intimated to the joint secretaries of the Board of Conciliation for the Regulation of the Wages in the Pig-Iron Trade of Scotland, that they have examined the employers' books for January, February and March, 1925, and certify that the average net selling price is 4*l.* 11*s.* 7*d.* per ton. This means that there will be a reduction in the wages of the workmen of 1 per cent. on basic rates.

NOTICES OF MEETINGS.

THE INSTITUTE OF COST AND WORKS ACCOUNTANTS.—To-day, at 10.30 a.m., at the Hotel Great Central, Marylebone-road, N.W. Annual Costing Conference. "Cost Accounting in Relation to Industrial Policy," by Mr. S. L. Gill and Mr. D. L. Moran. At 2.30 p.m., "Budgetary Control," by Mr. Perry Keene and Mr. F. T. Quennell.

THE ROYAL INSTITUTION OF GREAT BRITAIN.—To-day, at 5 p.m., at 21, Albemarle-street, W.1. Annual Meeting. At 9 p.m., "Crystalline Structure of Inorganic Salts," by Professor W. L. Bragg. Monday, May 4, at 5 p.m., General Meeting.

THE JUNIOR INSTITUTION OF ENGINEERS.—To-night, at 7.30 p.m., at 39, Victoria-street, S.W.1 Lecturette, "Pumps and Pumping Problems," by Mr. A. A. Fairfax.

THE INSTITUTE OF BRITISH FOUNDRYMEN : LANCASHIRE BRANCH.—Saturday, May 2, at 4 p.m., at the College of Technology, Manchester. Lecture : "The Importance of Venting, with special reference to Defective Castings," by Mr. E. Longden.

THE ROYAL COLLEGE OF SCIENCE ASSOCIATION.—Monday, May 4, at 5 p.m., in the Chemical Lecture Theatre of the old Royal College of Science, Exhibition-road, South Kensington, S.W.7. Lecture : "Thomas Henry Huxley," by Professor E. B. Poulton, F.R.S.

THE SURVEYORS' INSTITUTION.—Monday, May 4, at 8 p.m., at Great George-street, S.W.1. "New Methods and Materials for Building Working-Class Dwellings," by Major H. Barnes.

THE ROYAL SOCIETY OF ARTS.—Monday, May 4, at 8 p.m., at John-street, Adelphi, W.C.2. Howard Lectures : "Motor Fuels" (Lecture III.), by Professor John S. S. Brame, F.I.C., F.C.S. Wednesday, May 6, at 8 p.m. Ordinary Meeting. "Commercial Aviation," by Air Vice-Marshal Sir William Sefton Brancker, K.C.B. Friday, May 8, at 4.30 p.m. Indian Section. "Indian Meteorology," by Sir Gilbert T. Walker, C.S.I., M.A., F.R.S.

THE INSTITUTION OF PETROLEUM TECHNOLOGISTS.—Tuesday, May 5, at 5.30 p.m., at the Royal Society of Arts, John-street, Adelphi, W.C.2. "Some Notes on Water Shut-off," by Mr. F. G. Rappoport, M.Inst.C.E., F.G.S.

THE INSTITUTION OF CIVIL ENGINEERS.—Tuesday, May 5, at 6 p.m., at Great George-street, S.W.1. Thirty-first James Forrest Lecture : "Heavy Oil Engines : Some Outstanding Questions Relating to Large Engines of the Self-ignition Type," by Capt. H. Riall Sankey, C.B., Wednesday, May 6, at 6 p.m. Extra Meeting. Joint Meeting with the following bodies :—The Institution of Mechanical Engineers, The Institution of Electrical Engineers, The Institution of Naval Architects, The Institute of Marine Engineers, The North-East Coast Institution of Engineers and Shipbuilders, The Institution of Engineers and Shipbuilders in Scotland, &c., which are co-operating in the work of the Special Committee on Tabulating the Results of Heat-Engine Trials. Subject to be submitted for discussion : "A Standard Code for Tabulating the Results of a Heavy-Oil Engine Trial," by Mr. J. Carnaghan.

THE INSTITUTION OF ELECTRICAL ENGINEERS.—Wednesday, May 6, at 6 p.m., at Savoy-place, Victoria-embankment, W.C.2. Wireless Section Meeting : "Report on Measurements made on Signal Strength at Great Distances during 1922 and 1923, by an Expedition sent to Australia," by Capt. H. J. Round, Mr. T. L. Eckersley, Mr. K. Tremellen and Mr. F. L. Lunnon.

THE INSTITUTE OF METALS.—Wednesday, May 6, at 8 p.m., at the Institution of Mechanical Engineers, Storey's-gate, S.W.1. Fifteenth Annual May Lecture : "The Motion of Electricity in Metals," by Professor Dr. H. A. Lorentz.

THE IRON AND STEEL INSTITUTE.—Annual Meeting, Thursday, May 7, and Friday, May 8, at the Institution of Civil Engineers, Great George-street, S.W.1. Thursday, May 7, at 10 a.m. Presentation of the Bessemer Medal to Professor Thomas Turner. Presidential Address by Sir Frederick Mills. Papers to be read and discussed :—"Progress in British Rolling Mill Practice," by Mr. T. W. Hand. "'Flakes' or 'Hair Cracks' in Chromium Steel, with a discussion on 'Shattered Zones' and 'Transverse Fissures' in Rails," by Mr. A. Hultgren. At 2.30 p.m., "The Detection of Strain in Mild Steels," by Mr. T. Henry Turner and Mr. J. D. Jevons. "Strain Detection in Mild Steel by Special Etching," by Mr. J. D. Jevons. "The Effect of Grain upon the Fatigue Strength of Steels," by Dr. L. Aitchison and Mr. L. W. Johnson. "The Influence of Gases at High Temperatures upon Iron, with special reference to the Formation of Blowholes," by Mr. A. G. Lobley and Mr. C. L. Betts. At 7 p.m., Annual Dinner, in the Grand Hall, Hotel Cecil, Strand, W.C.2. Friday, May 8, at 10 a.m.: "Temper-brittleness of Steel : Susceptibility to Temper-brittleness in Relation to Chemical Composition," by Mr. R. H. Greaves and Mr. J. A. Jones. "'Peeling' in White Heart Malleable," by Mr. D. H. Ingall and Mr. H. Field. "Some Notes on the Use of a Diamond Pyramid for Hardness Testing," by Mr. R. L. Smith and Mr. G. E. Sandland. "Observations on Martensite and Troostite," by Mr. J. H. Whiteley. "On the Structure of Quenched Carbon Steels," by Mr. B. D. Enlund. "A Method for Reducing the Percentage of Phosphorus in Swedish Iron by diminishing the Phosphorus in the Charcoal," by Dr. H. von Eckermann. "Estimation of Phosphorus in the presence of Vanadium," by Mr. G. Watson Gray and Mr. C. D. Garbutt, "Note on Nitrogen as a possible Factor in Temper-Brittleness," by Mr. W. T. Griffiths.

THE INSTITUTION OF MECHANICAL ENGINEERS : NORTH-WESTERN BRANCH.—Thursday, May 7, at 7 p.m., at the Engineers' Club, Albert-square, Manchester. Fourth Report of the Steam-Nozzles Research Committee.

THE INSTITUTION OF MECHANICAL ENGINEERS.—Friday, May 8, at 6 p.m., at Storey's-gate, S.W.1 Extra General Meeting. Fourth Report of the Steam-Nozzles Research Committee.

THE INSTITUTION OF AERONAUTICAL ENGINEERS.—Friday, May 8, at 6.30 p.m., at the Engineers' Club, Coventry-street, W.1. "Lessons of 1924," by Capt. W. H. Sayers.

THE INSTITUTION OF MUNICIPAL AND COUNTY ENGINEERS : SOUTH-EASTERN DISTRICT.—Saturday, May 9, at 11.15 a.m., at the Town Hall, Worthing. Discussion on "Recent Municipal Works in Worthing." Various Visits.

NOTES FROM THE SOUTH-WEST.

CARDIFF, Wednesday.

Coal Trimming and Despatch.—A scheme for the regulation of coal trimming at the South Wales ports which, it is claimed, would facilitate despatch, was submitted to a meeting of the Cardiff District Shipping Federation yesterday, by Mr. W. Stanley Hinde, of W. E. Hinde and Co., managers of the Portfield Steamship Company, Limited. Mr. Hinde has put the scheme forward in view of the alarming reductions shown in the tonnage returns of steamers using the ports, and owing to the fact that prompt despatch is affected by the efficiency or non-efficiency of dock labour and the number of daily hours of work obtaining at the port. With regard to coal trimming, he points out that under the present system the men, more than any other grade of dock labour, are their own masters, and that the clearing-house officials have not the control of trimming that is desirable. The independence of the trimmers has always been a stumbling block to the speeding up of loading operations. The men of one gang receive the same pay as the men of another gang, and it does not matter on which ship a man works, his wages are the same as the others. Mr. Hinde submits that the trimming shall be carried out by coal stevedores, the direct employees of the shipowners, the stevedores to engage their own men and pay them. The stevedores will also collect the tipping and mixing orders and deposit them at the dock office, besides co-operating with the dock officials and shippers regarding bringing coal forward. The stevedores are also to appoint a leading trimmer on each ship, whose duty will be to co-operate with the ship's officers and berthing masters on trimming matters. The clearing house would continue for the purpose of rating vessels, and as an organisation to which disputes might be referred. For the present, the trimming rates would continue on the basis of the present tariff, but, in any case, rate-cutting should not at any time be allowed to undermine the system. The selection of stevedores would be made by the clearing house and approved by the dock company, by whom they should be licensed. For a short period, at any rate, an equal division of the work should be made by the shipowners between the various stevedores. The advantages of the scheme pointed out Mr. Hinde, was payment by results, and an incentive to maximum effort. The exployers would know who they were employing, and the men would know for whom they were working, while the leading trimmers or foremen would always be standing by the ship and looking for ways and means of saving time. The scheme was referred to the employers' representatives on the Trimming Board for consideration.

BUSK STUDENTSHIP IN AERONAUTICS.—The trustees of the Busk Studentship in Aeronautics have announced that an appointment will be made in the near future. The studentship is of the value of about £150, tenable for one year from October 1, but a student may be re-appointed on the same terms for a second year. It is open to any man or woman who is a British subject, not of Asiatic or African descent, and who had not attained the age of 25 years on October 1, 1924. All inquiries regarding the studentship should be addressed to Professor B. Melvill Jones, of Cambridge University, who will supply application forms to candidates.

EXHIBITION OF TURNERS' WORK.—Some admirable examples of the turner's art were to be seen at the exhibition held in the Mansion House from Wednesday to Friday last week. The exhibition was arranged by the Worshipful Company of Turners, and all the work on view had been entered for one or other of the groups in the thirty-eighth prize competition promoted by the Company. The competition was divided into two main sections, the first being for work executed in material other than metal, and the second for work in metal and alloys. A third section was open only to previous First Prizemen, and, as might have been anticipated, the competitors' work in this class was of a very high quality. The two main sections were divided into three classes, open, respectively, to workmen in the trade, apprentices or technical school students, and amateurs. A fourth class was added in the metal section open to apprentices or students not over 14 years of age. The Worshipful Company made a number of awards on the work submitted, the Premier award embracing the Freedom of the Company and the Freedom of the City of London (subject to the consent of the Court of Aldermen), in addition to a sum of five guineas.

THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY WEIR.

(*For Description, see Page* 532.)

FIG. 98. TRESTLE UNIT ON WEIR FLOOR.

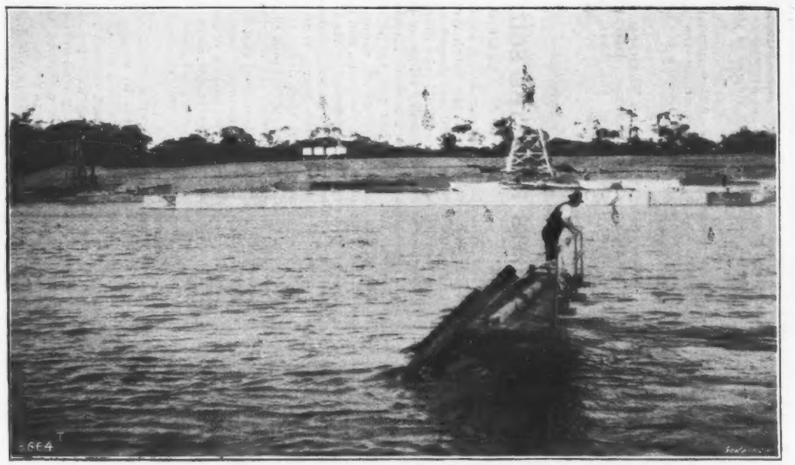


FIG. 100. TRESTLE UNIT BEING HAULED INTO POSITION.

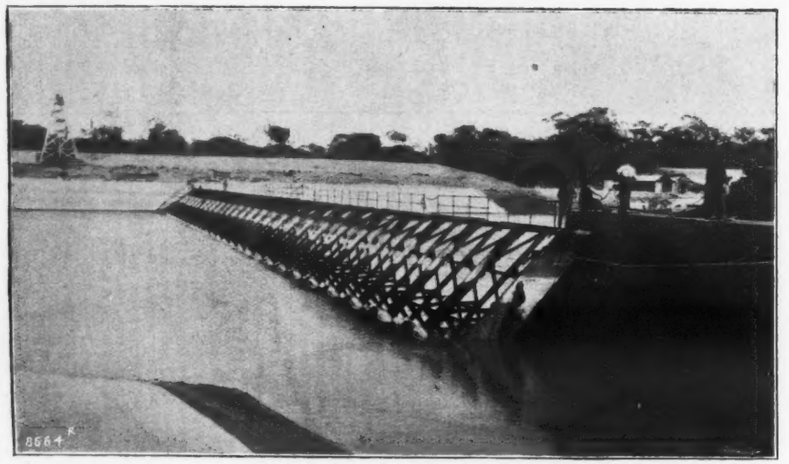


FIG. 99. TRESTLE UNITS IN POSITION FOR CLOSING CHANNEL.

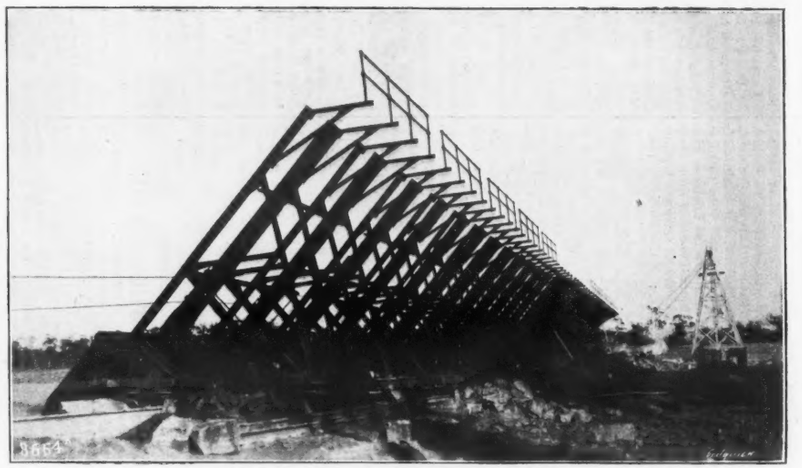


FIG. 101. TRESTLE UNITS HAULED UP ON SIDING TRACK.

FIG. 100. TRESTLE UNITS IN POSITION FOR CLOSING CHANNEL.

FIG. 101. TRESTLE UNITS HAULED UP ON SIDING TRACK.

THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY WEIR.

(For Description, see Page 532.)

Fig. 52. SECTION C.C. (LOOKING TOWARDS SLIDEWAY).

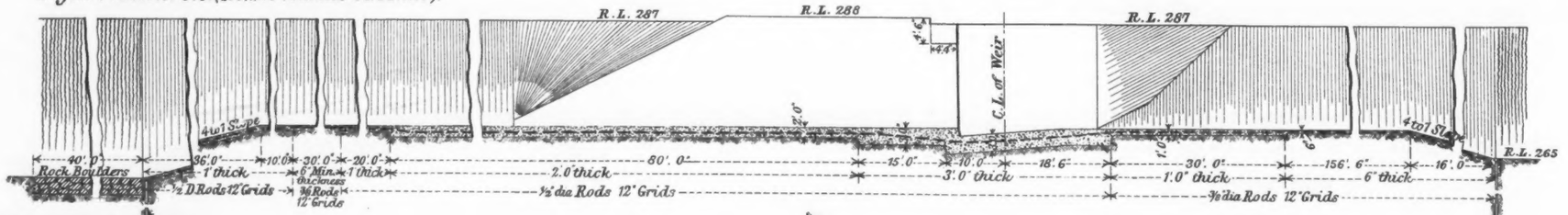


Fig. 53. SECTION C.C. (Fig. 25.)

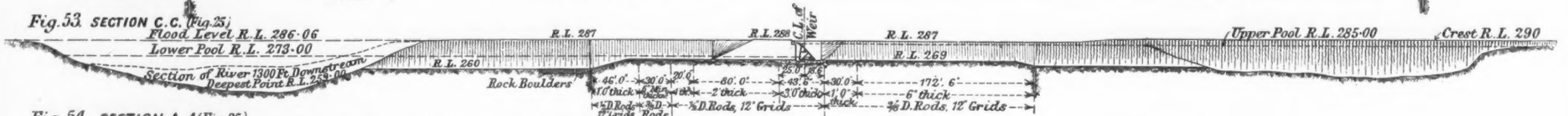


Fig. 54. SECTION A.A (Fig. 25)

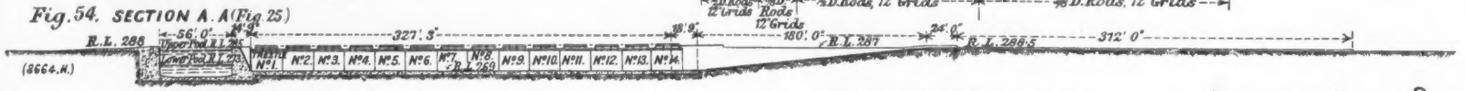


Fig. 55. SECTION A. A. (Fig. 57)

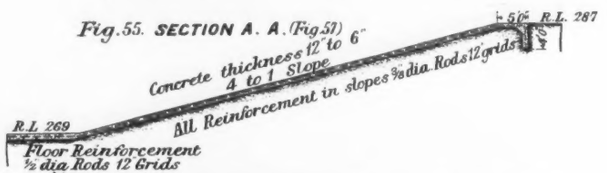


Fig. 56. SECTION E.E. (Fig. 57.)

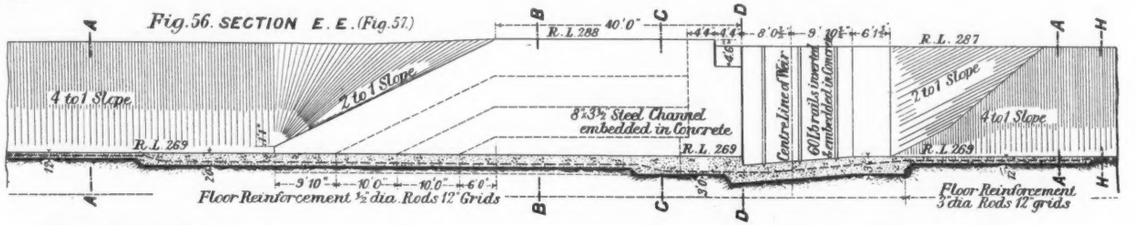


Fig. 57.

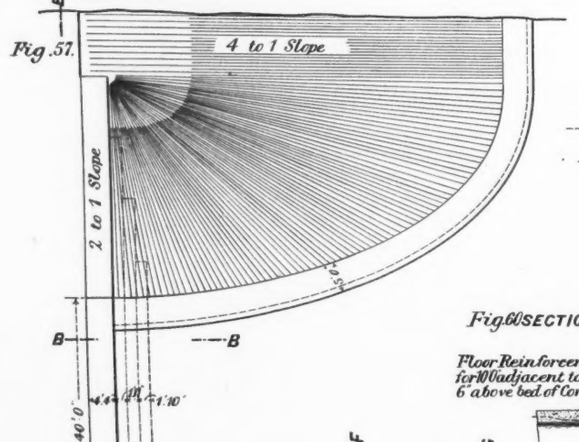


Fig. 58. SECTION D.D.

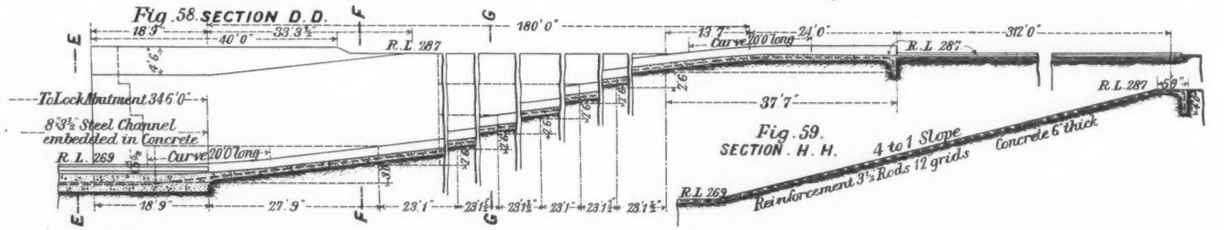


Fig. 59. SECTION. H. H.

Fig. 60 SECTION B B

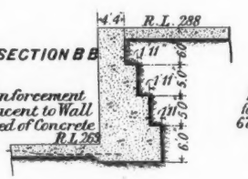


Fig. 61. SECTION C.C. (Fig. 57)

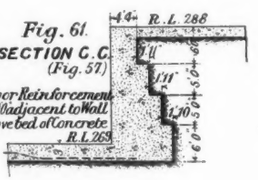


Fig. 62. SECTION F.F.

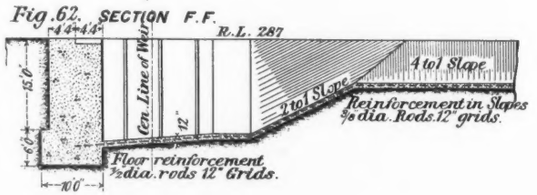


Fig. 63. SECTION G.G.

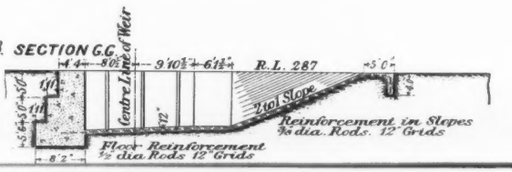
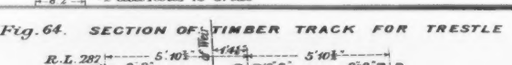


Fig. 64. SECTION OF TIMBER TRACK FOR TRESTLE



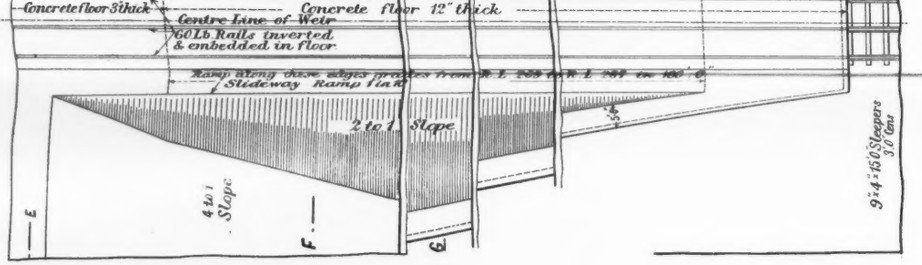
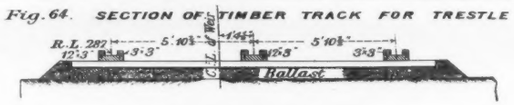

Concrete floor 3 thick
Concrete floor 12" thick.
Centre Line of Weir
60 Lb Rails inverted & embedded in floor
Ramp along these edges grades from R.L. 288 to R.L. 281 in 100'-0"
Slideway Ramp Track
2 to 1 Slope
4 to 1 Slope
9'-4" x 16'0 Sleepers 3'0 Crs

Fig. 64. SECTION OF TIMBER TRACK FOR TRESTLE



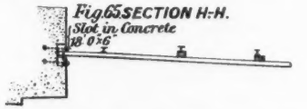


Fig. 66. SECTION (LOOKING TOWARDS LOCK)

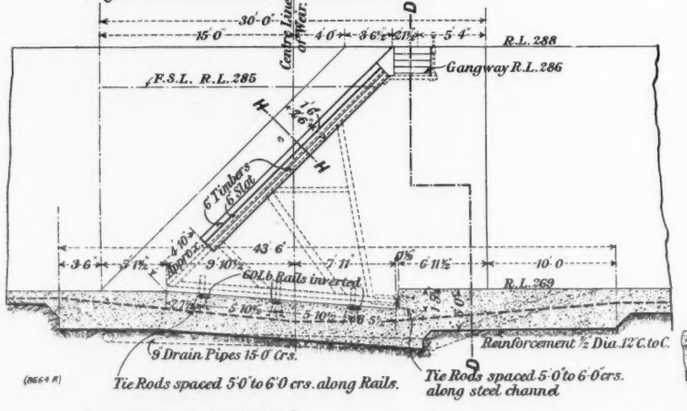

Centre Line of Weir
R.L. 288
Gangway R.L. 286
F.S.L. R.L. 285
6" Timbers to Slot
60 Lb Rails inverted
R.L. 269
9" Drain Pipes 15'0 Crs.
Tie Rods spaced 5'0 to 6'0 crs. along Rails.
Reinforcement 1/2 Dia. 12" C. to C.
Tie Rods spaced 5'0 to 6'0 crs. along steel channel

Fig. 67. SECTION D.D. (Fig. 66)

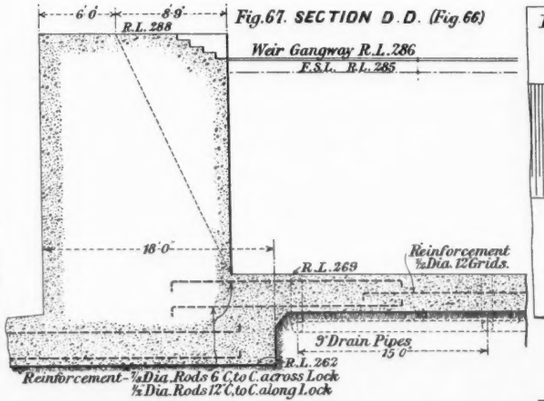
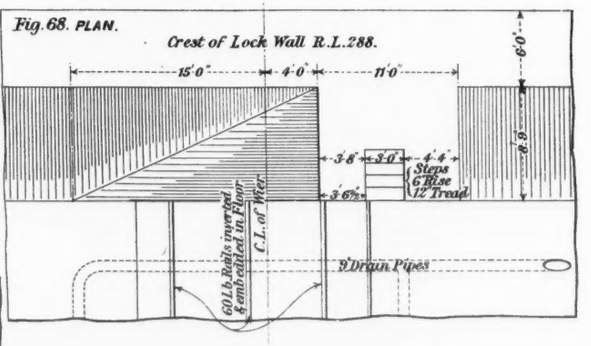

R.L. 288
Weir Gangway R.L. 286
F.S.L. R.L. 285
R.L. 269
Reinforcement 1/2 Dia. 12 Grids.
9" Drain Pipes 15'0
R.L. 262
Reinforcement 3/4 Dia. Rods 6' C. to C. across Lock
1/2 Dia. Rods 12" C. to C. along Lock

Fig. 68. PLAN.



END SECTION ON B.B. (Fig. 70)

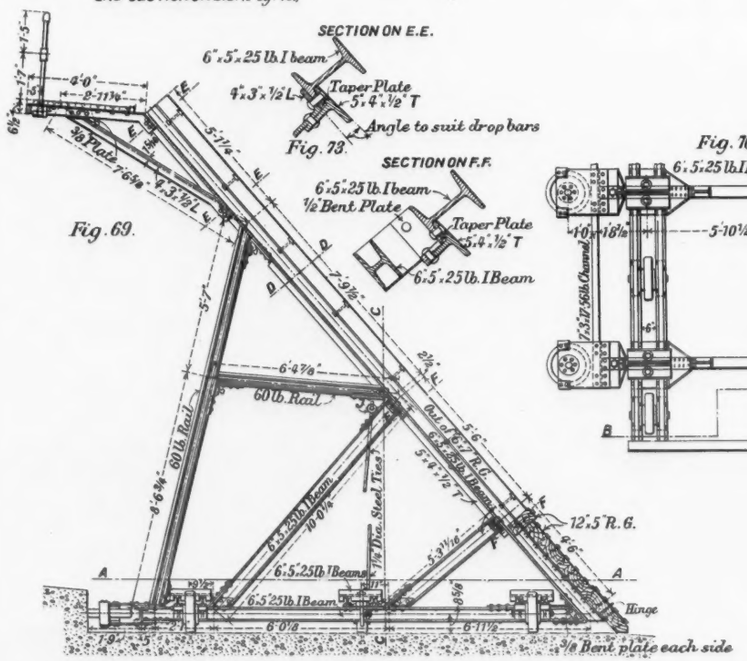
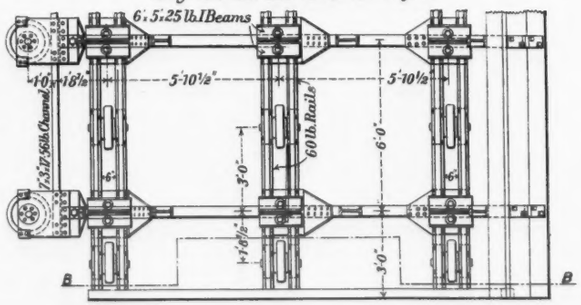
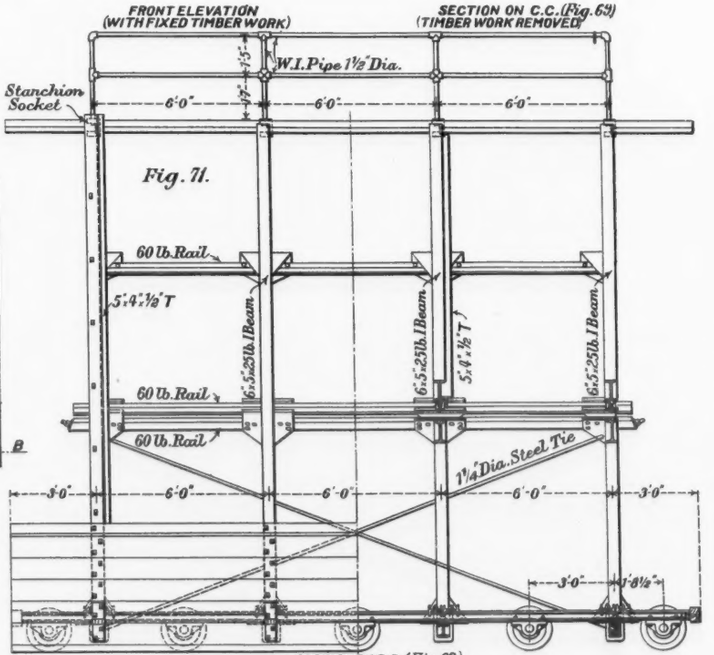

SECTION ON E.E.
6" x 5" x 25 lb. I beam
4" x 3" x 1/2 L
Taper Plate 5" x 4" x 1/2" T
Angle to suit drop bars
Fig. 73.
SECTION ON F.F.
6" x 5" x 25 lb. I beam
1/2 Bent Plate
Taper Plate 5" x 4" x 1/2" T
6" x 5" x 25 lb. I Beam
Fig. 69.
60 lb. Rail
12" 5 R.G.
Hinge
3/8 Bent plate each side

Fig. 70. PLAN SECTION ON A.A. (Fig. 69)




FRONT ELEVATION (WITH FIXED TIMBER WORK)
SECTION ON C.C. (Fig. 69) (TIMBER WORK REMOVED)
Stanchion Socket
W.I. Pipe 1 1/2" Dia.
Fig. 71.
60 lb. Rail
5" x 4" x 1/2" T
6" x 5" x 25 lb. I Beam
1 1/4" Dia. Steel Tie

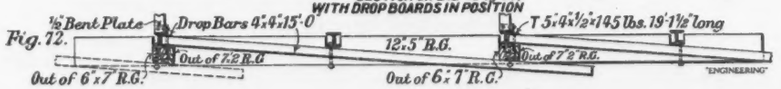

SECTION ON D.D (Fig 69) WITH DROP BOARDS IN POSITION
1/2 Bent Plate
Drop Bars 4" x 4" x 15'0
T 5" x 4" x 1/2" x 14.5 lbs. 19'-1 1/2" long
12" 5 R.G.
Out of 7" x 2" R.G.
Out of 6" x 7" R.G.

Fig. 72.

ENGINEERING.

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Advertisements intended for insertion in the current week's issue must be delivered not later than First Post on Thursday. In consequence of the necessity of going to press early with a portion of the edition, alterations for standing advertisements should be received 10 days previous to the day of publication.

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Two-Page Plate.—THE REGULATION OF THE MURRAY RIVER; TORRUMBARRY WEIR.

It is intended to undertake a "Life of the late Dr. W. H. Maw," Editor of ENGINEERING from 1870 to 1924, and President of the Institution of Civil Engineers, 1922–23. Those of his personal friends, colleagues or correspondents who may have interesting material, especially in the shape of personal reminiscences or letters, to contribute, are requested to communicate with Mr. W. E. Simnett, c/o The Institution of Civil Engineers, Great George-street, London, S.W.1.

ENGINEERING.

FRIDAY, MAY 1, 1925.

THE INTERNAL-COMBUSTION TURBINE.

IT is probable that the internal-combustion engine is more popular with the shipowner than with the sea-going engineer, although there are certain ocean routes on which the absence of boilers and of long ranges of hot steam piping may well be a subject for congratulation. It is, however, admitted that reciprocators require greater attention both at sea and in port than does the steam turbine. The story has, indeed, been told that in the early days of the marine turbine the complaint was made that it was difficult to keep the engine-room staff awake during prolonged destroyer trials because they had nothing to do. Could the high thermal efficiency of the Diesel engine be combined with the mechanical simplicity of the steam turbine, the gain would be great indeed, and it is natural therefore that the possibilities of such a development should constantly attract attention. During the last few weeks able papers on this subject have been submitted to three important provincial engineering societies. A perusal of these indicates that the problems involved are not materially nearer solution than they were in 1912.

No doubt undue pessimism is to be guarded against. Rumour has it that Sir Charles Parsons was assured by his original partners that his steam turbine would never return him a copper penny, and in view of the actual event it would be rash to conclude that a commercially valuable internal-combustion turbine will never be more than a Utopian dream. There is, however, one important difference between the conditions in technical circles in the 'eighties of last century and those of to-day. Forty years ago very few engineers had a competent knowledge either of thermodynamics or of hydraulics. Those who had fully realised the possibility of constructing successful steam turbines. Thus in 1885 Professor Unwin, in a lecture to the Institution of Civil Engineers, observed that, "So soon as we could find material strong enough and durable enough to stand an excessive speed [1,000 ft. a second] of that kind, we may have steam turbines much smaller and cheaper and not less efficient than ordinary steam engines." As is now general knowledge, Sir Charles Parsons turned the difficulty of high speeds by compounding, but some other engineers actually reached or exceeded Professor Unwin's limit.

It is very noteworthy that Professor Unwin felt that the difficulties to be surmounted lay mainly in the adaptation of our available materials of construction. It is this question of material which so far has prohibited the success of the internal-combustion turbine. There are no thermodynamic obstacles. Such a cycle as that embodied in Stirling's air engine would have a Carnot efficiency, but in practice any extended use of regenerators would involve unmanageably high working temperatures. Even without regeneration the temperatures encumbered are so high as to make it necessary to construct internal-combustion turbines as single-stage velocity compounded machines. The loss thus involved is two-fold. The velocity compounded wheel has a low intrinsic efficiency, and the single stage means that this will not be mitigated by an improved reheat factor. In a multi-stage turbine part of the energy dissipated in friction in the upper stages is recovered as useful work in the lower stages. In some steam turbines the gain thus accruing has been as much as 10 per cent., but single-stage machines have necessarily a reheat factor of unity whatever the ratio of expansion. Were it possible to construct an internal-combustion turbine as a multi-stage machine the gain from reheat would be greater than it is with steam, since the reheat factor is larger the greater the adiabatic index of the working fluid.

The production of new materials capable of maintaining their strength and substance at high temperatures would remove these present disabilities, and the experimental use of silica for this purpose, which is mentioned in Mr. König's paper to the North East Coast Institution of Engineers and Shipbuilders, is of great interest. Some of the properties of silica are ideal. It has a high melting point, it is not subject to oxidation, and its tensile strength is comparable with that of steel. Moreover it has a very low coefficient of expansion with temperature, and would thus be little liable to distortion. If, indeed, it approached steel as nearly in ductility as it does in strength, the problem might be considered solved if regarded from the purely technical standpoint, though probably not from the commercial one.

As matters stand, however, the designer of an internal-combustion turbine has to accept a low blading efficiency as one of the conditions imposed upon him, by the nature of the structural materials available. His difficulties, however, do not end here, since he also has to put up with a low compressor efficiency, and this is a very serious drawback, indeed. As Mr. Ferranti pointed out some years ago, the distinguishing characteristic of internal-combustion motors was the large proportion of the negative to the positive work, done in the cycle. He also insisted that the reciprocator was essentially a small unit motor, and the turbine inherently a large one. A leading gas-engine maker has, indeed, declared that as high an efficiency can be obtained with an engine of 60-h.p. as with the largest yet manufactured. It is, on the other hand, impracticable to attain high turbine efficiencies with small units, a consideration which makes experimenting on the internal-combustion type, a very expensive undertaking. Large units, however, require large compressors, which have accordingly to be of the turbine type. The efficiency of these can never approach that of the compression in a gas engine cylinder which is probably effected with an efficiency little short of unity. The conditions are indeed very similar to those in the cushion cylinder of the old Willans engine, in which the inertia forces on the up stroke were balanced by compression of air. Diagrams taken from this air cylinder had no appreciable net area, the compression and exhaust lines being practically coincident. Hence,

the compression must have been effected with nearly unity efficiency. About the highest figure claimed for turbine compressors is 80 per cent., and it is perhaps questionable whether this has ever been really attained. In some of the tests at any rate, in which figures of this order have been recorded, the method of test was not above criticism. In the case of a turbine compressor the reheat factor diminishes the net efficiency, since all the energy lost in blade friction in the earlier stages goes to heat the air, and thus increases the work to be done on further compression.

The effect of a poor compression on the overall efficiency of the internal-combustion turbine is very strikingly set forth in a nomograph included in the paper read by Professor W. J. Goudie last March before a meeting of the Institution of Engineers and Shipbuilders of Scotland.

In this paper, Professor Goudie showed that in one case considered, a reduction in the compressor efficiency from 65 per cent. to 55 per cent. would reduce the overall efficiency of the set from 0·20 to a negative quantity, so that power would have to be supplied to motor the plant round. The difficulties of a low compressor efficiency seem inherent, as there seems no prospect of any very substantial improvement in turbine compressors.

From Mr. König's paper, it appears that this has led in Germany to a revival or modification of Mr. H. A. Humphrey's proposal to use his pump to supply water under pressure to an hydraulic turbine. In the variant now being tried at Berlin, it appears that the two-cycle pump is being used, although in tests with this made before the war, it was not found practicable to attain as high an efficiency with the two-cycle as with the four-cycle type. With the latter the pressures attained are very high in the cushion stroke, and this fixes a limit to the diameter of the play pipe. Possibly, this limitation might be surmounted by constructing the latter as a tunnel, or as a well in solid rock. Such a well may be regarded as the bore of a cylinder of infinite outer diameter, and the maximum stress on the material could not then exceed the maximum working pressure.

Mr. König raises the objection that the Berlin plan would involve the use of a very large slow-running turbine, correspondingly expensive. It may be noted, however, that Mr. Humphrey showed that his pump could also be used as an air compressor, and it would be possible, therefore, to use this air for driving the turbine. Whether this suggestion has any advantages could only be settled by a detailed study.

As an alternative to regeneration, with its drawback of excessive working temperatures, many proposals have been made to use the heat of the exhaust for generating steam. The work of compression is then effected wholly or partly by steam power. Even so, however, the drawback remains that only a low-efficiency type of turbine can be used for the main element of the combination, and the figures given by Mr. König as to efficiencies actually realised by Mr. Holzwarth, are hardly encouraging. The best figure so far reached appears to be about 14 per cent., reckoned on the basis of shaft-horse-power. For ordinary oil engines, figures ranging from 30 per cent. to 35 per cent. are tabulated in *Kent's Mechanical Engineers' Handbook*, and still better figures are claimed for Diesel engines.

THE INSULATION OF ELECTRICAL MACHINERY.

WHILST modern studies of the electric discharge through gases and the technics of electronic emission practically owe their development to the creation of new types of vacuum pump, the nature of insulation by materials other than gases remains obscure, and there has been little change during the past twenty years in the general nature of the insulating materials of electrical engineering. That latter conclusion was arrived at by Colonel K. G. Maxwell and Mr. Allan Monkhouse in their review of "Recent Improvements in the Insulation of Electrical Machinery," discussed by the Institution of Electrical Engineers on the 23rd ult. They could, however, record improvements in the materials and methods of their application, as well as in the study of their properties and their testing and standardisation. But Colonel Maxwell considered that the British rating rules were only emerging from the melting-pot, and that further data, particularly on ageing and life tests, and on the effects of vibration, moisture and mechanical and electrical stress at extreme temperatures were desirable. Most of the standardisation tests were only applicable to raw materials, and not to finished products. In the "high-pressure or flash test" of the present day, 2 or 2½ times the full nominal volts were applied to a machine or apparatus, while still hot after the initial trial. Yet at no time was the insulation so vulnerable as just after that first temperature run. The volatile matter in the windings which would soon dry up in service, was concentrated during the trial in the cooler end portions. A flash test thus might break down a perfectly sound machine and necessitate a re-wind where only drying-out was required. The leakage test of Hartshorn by the aid of a bridge, instead of a wattmeter, would give early indication of a breakdown, and would avoid many unnecessary breakdowns. These statements were challenged at the meeting, but Mr. Monkhouse maintained the advantages of the cold test in his reply.

The Engineering Standards Association distinguishes as Class O, materials like cotton, silk, paper, &c., when unimpregnated, unvarnished and not used under oil, and as Class A, the same materials when impregnated, varnished, or under oil. In their tests made in oil, Messrs. Maxwell and Monkhouse found that cotton, sulphite wood pulp, chemically hydrated wood, manilla and jute ranked in this order at 20 deg. C., that jute failed badly above 80 deg., and that at 120 deg. cotton alone still remained a useful insulator, bearing 190 volts per mil. instead of 780 volts at 20 deg. They ascribed the superiority of cotton at high temperature to its freedom from lignin. Considerable progress had been achieved in the manufacture of special press boards which might ultimately replace laminated paper insulators. The introduction into press board of leather cuttings and rubber latex had so far not answered for high temperatures. There was little improvement to be expected in fabrics and tapes unless high prices were accepted; artificial silk had the advantage of absorbing little moisture, but it had not been tried sufficiently yet. As wire covering materials, paper, asbestos, enamel, spun glass and artificial silk were extensively utilised; but cotton remained the chief material, and it did not act merely as a spacer. They had, therefore, tried to improve the insulation value of cotton yarn by boiling the unbleached yarn in water or in 0·5 per cent. caustic soda, or by treating it with hot alcohol, petrol, and with a basic dye treatment; the dyed cotton maintained high insulation in damp atmosphere. The sensitiveness to moisture and the presence of conducting fibres of magnetite in asbestos were the drawbacks of asbestos wire coverings; but felted-on asbestos wires could easily be bent and were as deservedly popular as enamel and paper-insulated wires.

The statement that no insulating material caused its producers so much anxiety as the boards and tubes of bakelite and other synthetic resins of the phenolaldehyde type—the chief novelty of the past two decades—was strongly resented by several speakers, hardly for adequate reasons. The authors of the paper admitted that properly-made bakelite papers constituted an extremely good Class A insulation and possessed the advantage over shellac-paper that their temperatures might be raised above 100 deg. C., and even 150 deg. C., without softening or deterioration; but they could not be used at 160 deg. to 180 deg. The chief trouble with the better grades of bakelite was "tracking"; any arc formed became a conducting path for comparatively low potentials. Submitting all kinds of bakelite-paper board, shellac-paper board, hard press board, linseed-oil impregnated wood, micanite and vulcanised fibre to the E.R.A. standard fuse-wire test, Messrs. Maxwell and Monkhouse found that bakelite-papers, unless protected by special varnishes, failed almost invariably under the first test, whilst the other materials stood 6 to 20 applications. But small quantities of antioxygenes (hydroquinone, &c.), could cure tracking. Shellac-paper softened above 80 deg. unless subjected to long "curing"; but condenser terminals, 42 in. in diameter and 20 ft. long, had been made of cured paper. Colonel Maxwell did not recommend the blending of shellac and bakelite. Vulcanised fibre had deteriorated since the war, and should not be exposed to stress of more than 20 volts per mil. in dry situations.

Class B materials—mica, asbestos, and other refractory substances—may contain Class A materials, but only for structural purposes, and considerable latitude prevails in the interpretation of this rule. Colonel Maxwell issued a warning against the practice of basing mica percentages on weight instead of volume, in mica wraps for alternator bars, where figures higher than 45 per cent. by volume were almost unobtainable. Machine-built micanite was electrically and mechanically superior to the hand-built product, and "cushion-pressing," *i.e.*, placing a resilient material (thin felt or heavy cloth) between the mica sheets while being pressed, was recommendable. Most asbestos tape on the market being too expensive and too thick (12 to 20 mils.), an intermixture of 15 per cent. of cotton might be tolerated. Micanite was replacing block or pure mica, which was one of the Class C fireproof materials (earthenware, porcelain, quartz, &c.).

Varnishes, moulded compositions, insulating oils and bitumens and rubber have not yet been classified by the International Electrotechnical Commission, though of well-established importance; but there are some standard tests. Colonel Maxwell pointed out that the Russian petroleum formerly used for impregnation inclined less to sludging than the American oil of war-time, and that the Michie sludge test, which required 48 hours and very careful handling, could be replaced by the simpler Nuttall test.

Moulded compositions of synthetic resins, casein, and bitumens did excellent service if well manufactured and selected; but a black bituminous appearance was no guarantee of good insulation. Insulating processes and their appliances had been much improved during the last four years, and large factories now worked to definite specifications by scientific methods. As regards coil insulation for long bar conductors in high-speed machinery, practice was divided between the use of mica-silk tape applied by hand throughout, machine-wrapped bars fitted with micafolium in the slot and with end-connections taped with mica fabric, and green cell insulated bars in which wet mica cells built on fine jap paper were applied by hand. In all these cases the bars were pressed to shape after insulating. In coil-insulation much use was made of square and rectangular conductors; the bare conductors were bent and formed to shape, and the insulation of micanite, paper, &c., was inserted between them; the coil was then served with special enamels and insulated with tape. That practice required greater skill and attention, which were indeed the essence of all good insulation, but gave an improved space factor.

As regards varnish treatment, small parts were completely finished and varnished all over, together with the iron parts, which were afterwards wiped clean. Large parts had to be varnished before insertion, and there was the choice between vacuum impregnation and hot dipping. Colonel Maxwell decidedly preferred the latter, immediately preceded by hot baking to 120 deg. C. and followed by cooling in the varnish. Vacuum impregnation to some depth entailed the use of either a slow-drying varnish or of a varnish containing an excess of internal driers, both liable to release deteriorating acid compounds. In baking the goods should never be stewed in their own varnish fumes; the oven should be well ventilated, and the process carefully be controlled by the aid of thermo-couples and other devices. For bakelisation of synthetic resins the high temperatures and pressures formerly insisted upon were quite unnecessary; prolonged baking at 115 deg. to 120 deg. C. for 40 to 60 hours was quite sufficient. Such a temperature was far less likely to do any permanent damage to the organic constituents of the insulation.

MOTOR FUELS.

IN his second Howard lecture, delivered at the Royal Society of Arts on April 27, Professor Brame reviewed the possibilities of power alcohol. Alcohol, he considered, had definite advantages as a practical fuel. For its production in sufficient quantity on economical lines we were, however, dependent on raw materials which the tropical laboratories of Nature supplied in inexhaustible quantities, but from which we so far could not release the fuel by any simple practical method. Yet power alcohol had undoubtedly a future. Some day alcohol might be the only liquid fuel available, and before that period it would certainly become a fuel supplementary to petrol and benzol. Professor Brame's further remarks showed that it is already taking this position. With respect to denaturing he pointed out that the power methylated-spirits regulations of 1921 required a spirit of not less than 66 per cent. overproof, to which had been added not less than 2·5 per cent. of wood naphtha, 0·5 per cent. of crude pyridine, and 5 per cent. of benzol, the mixture to be coloured by 0·75 oz. of eosin and 0·25 oz. of "spirit red 3" to every 1,000 gallons. Before removal from bond not less than 25 per cent. of petrol, benzol or other approved substance must be added under Excise supervision, unless the spirit already contained 25 per cent. of denatured ether. Only when treated in this way might the spirit be distributed without further restriction.

Passing to fire risks and accidents, in which this country had a creditable record, Professor Brame tabulated the following flashpoints in degrees C.: petrol — 11 to — 30, benzene —12, toluene + 9 to 10, alcohol (95 per cent.) + 15 to 18, methyl alcohol + 10, power alcohol (5 per cent. benzol) + 1, motor benzol flashing at — 9 deg. C. The extreme minimum (and maximum) vapour explosive percentages of different observers averaged: petrols 1·5 (6), benzene 1·4 (7·5), ethyl alcohol 3·56 (18·0), methyl alcohol 7·05 (36·5). The figures for petrol and benzol were approximately the same, but the higher volatility of petrol rendered this substance more dangerous. Alcohol was much safer than either on account of its lower volatility, its higher explosive minimum, and, further, because of the low density of its vapour. Petrol vapour was three times as dense as air, benzene 2·5 times, alcohol 1·5 times; the heavier vapours collected on floors and in pits, and ignition would travel over considerable distances. Ignition temperatures varied much with the experimental conditions; giving the figures of Harold Moore and of Ricardo, Professor Brame showed that ethyl alcohol/air mixtures ignited only at 518 (or 514) deg. C., but petrol/air mixtures at 360 (353) deg. C. Referring to the risks of static electric charges, especially in filling tank wagons, Professor Brame spoke in favour of earthing the wagon by a trailing chain and the nozzle by the use of an armoured hose, and of metallic contact between the filling nozzle and the tank. To allow petrol to run down drains was against the regulations.

Of other properties of motor fuels, specific gravity was no longer regarded as a comparative criterion, except in cases of spirits derived from the same crude. On the other hand, vapour pressure was of value for grading fuels of different classes or for blends. As the quantity of vapour necessary to produce an explosive mixture in a cylinder changed with the temperature, it was customary to flood the carburettor and to inject spirit into a cold cylinder while choking the air supply. The boiling range was considered the best comparative test of motor fuels, and ease of starting was judged by the temperature at which 20 per cent. of the fuel would distil; that temperature ranged from 70 deg. C. to 80 deg. C. for aviation spirit, 85 deg. C. to 90 deg. C. for No. 1 petrol, and was 85 deg. C. for motor benzol, and also 85 deg. C. for benzol/petrol. For use at considerably reduced pressure, as in aviation, too high a volatility was often undesirable. Belgian aviation spirit had the lowest boiling constituents removed. Sparrow, experimenting in the United States altitude chambers, found that high volatility led to vaporisation in the fuel pipes, upsetting the carburation and finally stopping the engine, as well as to sufficient cooling to cause snow formation in damp air. The maximum boiling range (proportion of the fuel distilling above a certain arbitrary temperature) or "end point," should be high to increase the yield of petrol from a given crude oil, but it was limited, as already mentioned in the first lecture, by the incomplete evaporation and combustion of the high-boiling constituents in the cylinder. The British standard specification for petrol gave the end point 225 deg. C., but the average found for No. 1 petrol in this country was about 180 deg. C., and for aviation spirit 140 deg. C.; the ordinary end point of gasoline in the United States was 220 deg. C. The viscosity of a fuel was of direct importance in connection with the question of the size of the jet. For motor working the temperature coefficient was at least equally important. The viscosities for petrol, benzol, alcohol, were 100, 60, 22 at 0 deg. C. but the figures were 116, 116, 45 at 30 deg. C. Due to this a carburettor required a minimum amount of fuel and a maximum of air on a cold day, but more fuel and less air as the motor heated up.

THE ROLL OF HONOUR OF THE INSTITUTION OF ELECTRICAL ENGINEERS.

ALTHOUGH the memory of those of our blood who fell in the Great War is a national possession, it is laudable and natural that localities and associations should wish to have their own memorials. The effect of this desire has taken many forms, but it would be difficult to find a more praiseworthy example than the memorial volume which has been prepared by the Institution of Electrical Engineers. This Institution, in common with others, has erected tablets in the hall of its home on which are engraved the names of those who fell. Such a permanent record no member of the Institution would wish to be without, but the volume which has been prepared forms a worthy adjunct in which fuller details can be recorded, and which those to whom some name which appears in the record is much more than a name, may hold in personal possession.

The War Memorial Book, which has been prepared by the War Memorial Committee of the Institution, is a post-folio volume of 345 pages, containing biographical notices of the 162 members of the Institution who fell in the war. Portraits are also included in all but three cases. The biographical notices are preceded by an historical introduction dealing with the origin and causes of the war and written by Lieut.-Col. W. A. J. O'Meara, the editor. In a note appended to the volume, the late Mr. C. H. Wordingham, who acted as chairman of the War Memorial Committee, states that "it is difficult to find adequate words to express the indebtedness of the Committee" to Lieut.-Col. O'Meara. An examination of the book shows this praise to be well earned. The completeness of the details of the civil and military careers of the members dealt with is very remarkable, and shows that the task of collecting the records has been one of love and reverence. Very clearly no trouble has been too great which might add something to any of these stories of the fallen. To illustrate the records and assist in an understanding of their details, a series of maps of the various battle fronts is included in a folder at the end of the book.

This work has been in contemplation from the inception of the War Memorial Committee, and its preparation has taken over five years. In view of its completeness and the fact that it has involved the tracing of information from every part of the Empire, the period cannot have been too long. The book is a dignified volume, bound in khaki-coloured buckram, and its printing and form throughout reflect nothing but credit on the Institution and its printers, Messrs. Unwin Brothers. A copy of the work has been presented on behalf of the subscribers to the War Memorial Fund to the nearest relative of each fallen member. Additional copies have been printed and may be obtained by others at the price of 2 guineas each.

NOTES.

RELATIVITY.

IN a letter which appeared in *Nature* of April 18, Professor Michelson and Dr. Gale describe the results of a crucial experiment on the generalised theory of relativity. According to Newton a motion of rotation differed from a motion of translation in that the latter could be defined only by reference to some point assumed to be fixed in space, whilst a rotation was absolute, and the behaviour of Foucault's pendulum was accordingly understood as demonstrating the absolute rotation of the earth. In the doctrine of generalised relativity, rotations are considered to be as purely relative as linear velocities, and the results of Foucault's experiment were otherwise interpreted. According to the doctrine, moreover, it would be as impossible to detect a rotation relatively to the ether, as the famous Michelson-Morley experiment showed that it was to detect a translation through the ether. It is this doctrine of the relativity of rotations which has now been submitted to test by Professor Michelson and Dr. Gale, and they find that it be flatly contradicted by experiment. The "rotational drift" through the ether does exist and the agreement between calculation and observation is excellent. Newton's conclusion is thus vindicated, but the "restricted" theory of relativity may still remain valid.

THE EARTH'S CRUST.

The presidential address delivered on the 23rd ult., by Sir Thomas H. Holland, at the annual general meeting of the Institute of Mining and Metallurgy, consisted mainly of a brief review of recent advances made in ascertaining the chemical and physical characteristics of the earth. He stated that the figures obtained by F. W. Clarke and H. S. Washington, and published in Professional Paper 127, 1924, of the United States Geological Survey, expressed more clearly than any hitherto obtained, the average composition of the accessible parts of the earth's crust. Another paper recently contributed by E. D. Williamson and L. H. Adams, to the Journal of the Washington Academy of Science contained data from which it was possible to speculate upon the physical and chemical character of the deeper layers and even of the core of the earth. The physical evidence of the second paper and the chemical results of the first had been correlated by Washington who had come to the general conclusion that the distribution of the principal bases was roughly in accordance with their affinity for silica, the oxidisability of their metals and their order in the electro-chemical series. The more electro-negative are situated nearest the core of the earth, and the more electro-positive nearest the outer shell. The formation of our workable ore-deposits had given rise to much speculation, and two main theories had been propounded. The one maintained that ore bodies were the products of materials brought up from great depths, either in the form of molten magmas, or as solutions and gaseous emanations of hypogene origin. The other theory was to the effect that ore-concentrations were merely segregative re-arrangements of minerals already disseminated through the outermost film of the earth's crust. These theories were, however, more probably complementary than mutually antagonistic. A sketch survey of ore deposits taken in conjunction with the latest geo-physical results, seemed to show that the majority of the workable ore-deposits were the result of simple lateral segregation of the minerals disseminated originally through the crust, and even a large proportion of these were probably derived by segregative processes in the uppermost layers. The gradual working out of these natural concentrates was a matter of deep concern, and the theoretical speculation outlined might prove of use in solving the practical problem which would inevitably come to pass.

STATE ASSISTANCE TO GERMAN SHIPBUILDING.

Immediately after the Government's statement, obviously made in perfect good faith, that the German shipyards are not receiving any State subsidy for the construction of ships to foreign order comes the news that the railways have again reduced their

rates on shipbuilding materials by between thirty and thirty-five per cent. Such a reduction is of great importance to German shipbuilding, and there can be no doubt that this is a very effective form of subsidy. The railways are owned by the State, and the carriage of plates and ship materials from the inland iron and coal areas to the shipbuilding districts on the coast has always been a very large item in the expense account of a German shipyard. In the very early days of the German Navy, when the Imperial Dockyard at Wilhelmshaven was first established for the construction of men-of-war, the kingdom of Hanover refused to allow a railway to be laid within its borders, the result being that all the materials had to be taken to Wilhelmshaven by sea at an excessive cost. In those days practically all the other German yards bought their materials in England and imported them direct, but this was always a sore point with the German industrialists. In 1873 a great victory was gained when Marshal Stosch ordered that all German men-of-war were to be constructed in Germany and as far as possible with German materials. Bismarck followed this by insisting that all the ships that took advantage of the subsidies granted under his Imperial Mail Scheme should be built in German yards also, and, as they already had the privilege of bringing British shipbuilding materials into the country free of costs, he offered a sop to the iron industry by ordering the railway administration to reduce its rates of shipbuilding material by nearly fifty per cent. Without this concession it is doubtful whether the North German Lloyd could have fulfilled the conditions of the Imperial Mail Contract without collapsing altogether. This concession has been in force ever since, and has had a very material effect on the fortunes of the German shipbuilding industry. As German shipbuilding material is already very much cheaper than British, this latest reduction in transport charges will enable the German shipyards to underbid us on new construction even more than they have contrived to do hitherto, and its importance will not be lost upon shipbuilding interests in this country.

The Accessibility of Motor Vehicle Chassis.

The accessibility of the pleasure car chassis formed the subject of the last paper of the session, read by Mr. M. Platt before the Institution of Automobile Engineers on Tuesday last. From the discussion which followed the reading of the paper it was evident that this somewhat hackneyed question is capable of arousing keen interest, and that a wide divergence of opinion still exists as to the degree to which accessibility is desirable. We have previously had occasion to point out that the question may be viewed from two standpoints, that of the owner-driver and that of the repairer; and the confusion of these two points of view is a frequent cause of controversy. The owner-driver is chiefly concerned with the ease or otherwise with which he can maintain his car without extraneous aid in reasonably good condition; while the repairer is more immediately concerned with the amount of work involved in carrying out overhauls and repairs which are beyond the capability of the owner, either due to lack of knowledge or an insufficiency of the necessary appliances. The author was careful to make this distinction at the outset of his paper, but it was evident from the discussion that there was a feeling amongst manufacturers that many of the adjustments which he suggested as within the purview of the owner-driver should more properly be regarded as the work of the repairer. It is, of course, an open question as to what extent the former is competent to make adjustments of any kind, but we believe that the view expressed by one of the speakers, that the average owner should be regarded as incompetent to perform anything beyond greasing up and making the very simplest adjustments, is essentially sound. If this view is accepted, the degree of accessibility, which leads the owner into the temptation of making purely experimental adjustments, becomes unnecessary; and the assumption can safely be made that any necessary alterations to take up wear will be made by the repairer. It is the owner's business to ascertain that the latter is reasonably skilled, and the assumption can then fairly be made that he will possess any special tools that may be required. Ever since the early days of ordinary bicycles, there has been a demand on the part of the public that every nut should possess sufficient clearance, and should be of such a form, that it can be removed with an ordinary shifting spanner, and the remarks of one or two of the speakers who joined in the discussion gave the impression that the same attitude existed amongst skilled engineers. No doubt the conception is admirable as an ideal, but put into practice it involves an increase in the size and weight of parts which far outweighs the advantage gained. The discussion should serve a useful purpose in helping to remove the mischievous idea that designers ignore accessibility. There can be no reasonable doubt that the question receives the most careful attention in the majority of cases, but the attitude of the responsible designer was aptly expressed by one of the speakers when he stated that mechanical efficiency must not be sacrificed for the sake of accessibility.

Continuous Distillation of Petroleum.

The question which Mr. A. M. O'Brien, F.I.C., raised in his paper on "Continuous Distillation of Petroleum," read before the Institution of Chemical Engineers last week, was whether the economy of continuous oil distillation could not be improved by proportioning the sizes of the separate stills of a unit to the duty which each has to perform. In ordinary practice all the stills of a unit, which may consist of as many as 40 stills in which the oil gravitates from one into the other, are of the same size. Taking the case of a petroleum containing fractions of 20 per cent. of naphtha, 30 per cent. of kerosene, 15 per cent. of solar oil, &c., to be distilled down to a residue of 30 per cent. or 35 per cent. in a unit of six stills, Mr. O'Brien showed that if in the first two sections of two and three stills each percentage of the first two fractions had 13 sq. ft. of evaporative surface allocated to it; there would only be 9 sq. ft. available in the third section of one still, and the rate of distillation would thus not be uniform. Even if the flow of oil in the first two sections were slowed down, and the rate of evaporation speeded up in the third section, the maximum amount of evaporation realisable per square foot of evaporative surface in unit time would not be obtained. With progressive distillation in single stills of equal size there would be a diminution in the load on each still. The temperature should be raised as the boiling-point of the residual oil rose; the specific heats of the various constituents differed only in the third decimal, but the latent heats differed considerably, and the vapour pressures of the lubricating oils being lower than those of the petrol fractions, the initial stills should receive more heat (not less) than the final stills. Mr. O'Brien showed how it was possible to reduce progressively the still sizes both in length and diameter, while keeping the still level in the setting constant, and also how to proportion the rate of feed and to adjust the temperatures and the pressures. His condensers would likewise be of diminishing size, the whole of the water passing first into the condenser of the initial still and then into the others. There would be by these arrangements a saving in structural material and in cooling water. This system of proportioned stills has not yet been tried, and the discussion following the paper, though favourable to an inquiry, was, on the whole, critical. One of the chief objections taken by Messrs. Anfilogoff, Lomax, Lessing, and other speakers was that Mr. O'Brien apparently pre-supposed constant supplies of uniform products, whilst many refineries have to deal with varying raw materials, and that he seemed to discuss distillation rather than fractionation. Mr. Anfilogoff further objected that the refineries had frequently to be built on marshy ground near the oil-field, and that engineers had quite enough trouble with the foundations when the loads were uniformly distributed. It was, further, wrong to diminish the sizes of the condenser for the higher fractions, particularly as free steam had to be introduced into those stills in order to facilitate evaporation; Dr. Lessing pointed out that a large condenser acted like a steadying flywheel. It would, again, be more difficult to cut out one still for repair if they were not all of equal sizes, and such a plant would generally be less flexible than the present plants.

THE NIGERIAN RAILWAYS.

Some two years ago we dealt in these columns with reports by Lieutenant Colonel F. D. H. Hammond, C.B.E., D.S.O., R.E., on the railways in British Territories in East Africa and the Gold Coast Railways.

The recent visit of H.R.H. the Prince of Wales to Nigeria, where he has travelled over the whole railway system, lends special interest to a further report by this officer which was drawn up following a tour of the railways of Nigeria. This has lately been issued by the Crown Agents for the Colonies. It is perhaps worthy of note that when Colonel Hammond made this inspection the Colonial Secretary was a railway man, the Rt. Hon. J. H. Thomas, P.C., M.P., and that the tour was apparently the result of complaints by the Chambers of Commerce of London, Liverpool, and Manchester, and the West African Merchants. The report certainly seems to show that some of these complaints were only too well founded.

Lieutenant-Colonel Hammond spent some four months, from November to April, 1924, in a thorough investigation of the internal organisation, the working methods of the railway department, and the conduct of its business alike with the public, and with other Government departments. During his stay in the Colony he made at the request of the Government interim reports on various matters on which it was desirable to take early action. Amongst the principal subjects so treated were the realignment and relaying of the railway between Minna and Kaduna, the inauguration of reconnaissances and traffic surveys for feeder lines, the choice of a site for the headquarters and stores of the Eastern Division, and the extension of the new railway to Jos.

The railway system of Nigeria is composed of two main lines, shown in the map opposite, which are unconnected with each other. The larger is based on the port of Lagos and consists of 968 route miles, while the smaller is based on Port Harcourt, and has a route mileage of 158, making a total of 1,126 route miles, for the whole system of which 983 are of 3 ft. 6 in., and 143 of 2 ft. 6 in. gauge.

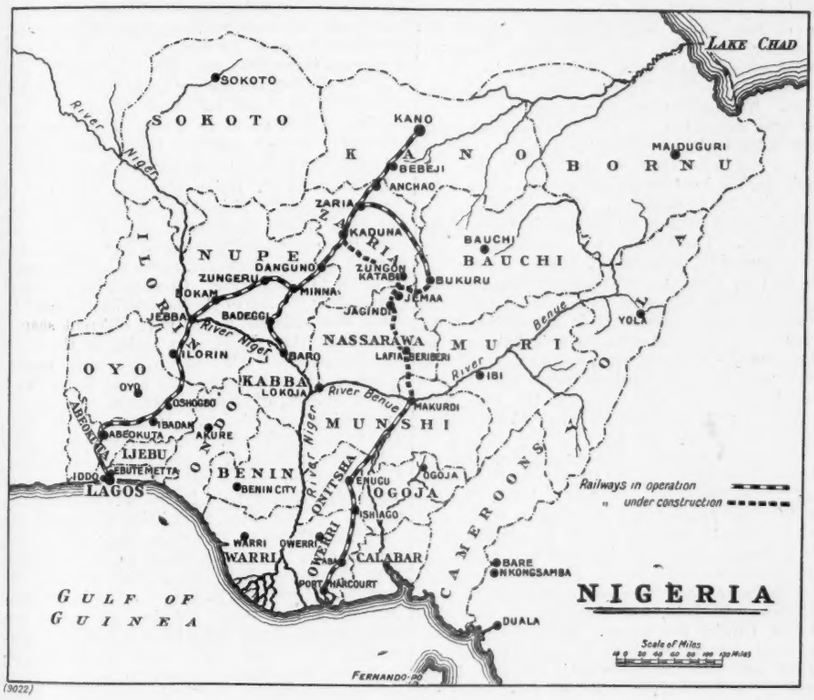
The terminus of the Western line is on Iddo Island in the Lagos lagoon. There is no rail connection with the town of Lagos itself, where the main deep water wharf used for the mail boats is situated. At Iddo, are wharves for small ocean craft, and barges. Four deep water wharves capable of taking the largest boats in the West African trade are being constructed at Apapa on the opposite shore of the lagoon to Lagos, and connected by a branch line to Ebute Metta. These wharves and the improvements made in recent years in the port of Lagos were described in ENGINEERING, vol. cxvi, page 137.

From Iddo to Ibadan the maximum gradients used are 1·00 per cent. in a downwards, and 1·25 per cent. in an up-country direction, compensated for curvature in both cases. The maximum curve used is 10 degrees. This section of 120 miles has recently been relaid with new 80-lb. rails, 16 sleepers to the 40-ft. rail length. Steel sleepers are used throughout, except on bridges and turnouts. At Aro there is a short 1¾ mile branch to the city of Abeokuta, and another small branch 2 miles long between Ifo junction and Ifo town. A third small branch connects Iju junction with Iju waterworks. From Ibadan to Minna the same standard gradients are kept except one of 1·25 per cent. on which banking engines have to be used At Jebba the railway crosses the Niger by two bridges. The first is of 7 spans of 185 ft. each with approach viaducts of three 30 ft. concrete arches at each end; the second connecting the island to the north bank consists of two spans of 150 ft., two spans of 105 ft., with two 30-ft. arches at each end. From Jebba to Minna, and from there to the terminus at Kano 45 lb. rails are used, with 12 sleepers to the 30 ft. rail. Between Minna and Zaria the maximum gradient is 1·5 per cent. From Minna a branch runs southerly 111 miles to Baro.

At Zaria a 2 ft. 6 in. gauge, the Bauchi Light Railway, connects the tin fields with the main line. This is 143 miles in extent, the terminus being Bukuru. The maximum gradient are 2 per cent.

The Eastern line based on Port Harcourt was put down to tap the coal fields at Enugu. At Port Harcourt are deep water wharves and a high level tip. The gauge of the line is 3 ft. 6 in., the rails 60 lb., the distance from Port Harcourt to Enugu is 151 miles.

The headquarters of the railways together with the principal locomotive workshops are at Ebute Metta on the Western line. The Eastern line where electric light and power plant for the use of new workshops and the colliery have been erected at Enugu, is in charge of a divisional superintendent, but the representative of the various departments correspond with headquarters at Ebute Metta, and not to the divisional superintendent. The colliery is under a colliery manager responsible to the general manager. The



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colliery accounts are kept entirely separate from those of the railway.

The Western line for 200 miles runs through thickly populated country, the main products being palm kernels, cocoa, palm oil, and cotton. From there up to Zaria the population is scanty and traffic negligible, except for fair returns from the Baro branch. North of Zaria the population becomes very dense, exports being ground nuts, hides, skins, and cotton. On the Bauchi Light Railway, the exports are cotton from the West, and tin concentrates from the East. The principle traffic of the Eastern line is coal, and a large quantity of palm oil. The Eastern line is being continued from Enugu to Makurdi, crossing the river by ferry, and continuing north and westerly joining the main line at Kaduna junction. A little north of Jemma a 50-mile branch line will connect up the Bauchi Light Railway from Zaria at Bukuru.

At the time of Lieut.-Colonel Hammond's arrival, there were four districts with headquarters at Ebute Metta, Minna, Zaria and Port Harcourt. It had long been recognised that the distribution on the Western line had disadvantages. The traffic did not coincide with the locomotive districts, and the district headquarters of the two departments were situated at stations a long way apart, except at Ebute Metta. As an assistant traffic superintendent with a large staff had to be kept at the docks at Iddo, the districts were altered as follows: The Ebute Metta district, with headquarters at Iddo, including the line to the station south of Ibadan. The Offa district, with headquarters at Offa, from Ibadan to Minna, exclusive. The Zaria district, headquarters at Zaria, including the main line from Minna, inclusive, to Kano, the branch to Baro, and the Bauchi Light Railway.

The operation of traffic is carried out in theory by the district traffic superintendent. Weekly trains ordering notices are issued giving the general programme for the following week. Every morning all stations wire in yard reports. Intermediate train orders are then issued by telegraph ordering such trains as the yard report show to be required. These orders relate to the trains due to run on the following day. Orders for power are at the same time given to locomotive foremen, who order the engines, and note spare engines or trains for which they have not power. It is clear that these intermediate train orders are the means by which the actual operation of traffic is carried out, and there are not less than five principal train-ordering authorities on this line, some being of quite junior rank, each only considering his own section. Some of them frankly stated during the inquiry that they considered their first duty was to their own section, for which they cannot well be blamed. Instances were brought to notice where engines had been run back light, when they might have been employed for a return journey on the adjoining section, and, being returned with a useful load to their home station, in time to handle the traffic there.

The traffic manager, although he receives daily reports, appears to have been out of touch with the general requirements, and to take little active part in the ordering of trains. During the months of December and January, when the heaviest traffic season was in full swing, only three important orders emanated from the traffic manager's office. One issued when it was clear that there would be ground-nut traffic, directed that all empties should be despatched to Kano. The second, which detailed the conditions under which open trucks could be used for the same traffic, became ineffective after a short time, as the merchants declined to accept them any longer. The third related to the cancellation of a ballast train, and was issued three days after the train had ceased running. The table in the next column giving statistics of goods vehicle service in Nigeria and in other colonies is interesting.

The three reasons pleaded in extenuation of delays were the seasonal nature of the traffic, the shortage of motive power, and the practice of keeping wagons under load at Iddo wharf, but these were not alone responsible for bad wagon usage. Figures in the report show delay to trucks of whole consignments at times when these excuses did not hold good. The Kano Chamber of Commerce complained of delays and supported their complaints with actual instances. Other departments of the railway also complained of delays to urgent consignments which were not due to the stores department.

Railways.	No. of Goods Vehicles.	Mean Mileage of Lines Worked.	Net Goods Ton Miles.	Net Goods Ton Miles per Vehicle.
Nigeria, 1922-23 ..	3,060	1,126	124,870,935	40,807
Mashonaland, 1922	2,330	1,865	443,932,036	190,529
Uganda, 1922 ..	1,448	709	99,994,044	69,057
Sudan, 1921 ..	993	1,489	138,996,965	139,977

Lieut.-Colonel Hammond states that the chief cause of delay in moving the seasons ground-nut crop from Kano, were detention of trucks at Iddo wharf, where, owing to the awkward siteing of the export sheds, merchants were allowed to keep trucks under load, instead of off-loading into the sheds; when Apapa is taken into use this evil will be cured. Delay is also due to the shortage of motive power, but is not due to shortage of wagons.

A Traffic Training School is in existence and has achieved good results. This is significant. This department is the only one which has tackled the training of the African in a systematic fashion.

In dealing with the locomotive department Lieut.-Colonel Hammond states that the present workshop facilities were recognised in 1914 as being inadequate, but proposals for extension were held up owing to the war, and new shops were only completed in January, 1924; 43 per cent. of the 3-ft. 6-in. gauge and 50 per cent. of the Bauchi Light Railway engines were under repair, the high proportion being due to want of workshop facilities. In addition to this, delay in transport arose from a shortage of drivers, full use being made of those available. A scheme is recommended in the report for training native engine drivers to replace or assist European drivers, when expansion is needed to meet rushes of traffic. The maintenance of engines in service is said to have been good.

With regard to the 3 ft. 6 in. gauge engines, owing to inadequate repair facilities, the railway has been forced in order to cope with the increased traffic, and the requirements of new extensions, etc., to buy new engines to take the place of those which they could not repair. The blame for this cannot be laid on the shoulders of the running branch. Of the 15 engines on the Bauchi Light Railway at the date of the inspection, two were unserviceable; three were shunting engines. Half of the remainder were in service, and the other five undergoing general repair. Four of these engines had been in continuous service since 1912. The continuous work to which they had been subjected had developed boiler troubles, and they had been stopped by the boiler inspector as too dangerous to continue in service. The average mileage per engine is about 22,000 engine-miles per annum, and under the climatic conditions, does not compare unfavourably with other countries. Of the engines which were in running order the number of failures were few. In 1923 the failures were 28, while the engine-miles per failure were 47,172.

The shortage of drivers was caused by the produce traffic being far heavier than anticipated. This lack of foresight affected not only the railway department but the commercial community also, who did not anticipate the large supply of ground nuts. In training the native to qualify as a locomotive driver, Lieut.-Colonel Hammond recommends that the English practice be departed from, as in order to get the most suitable and intelligent type of native driver, class prejudices have to be considered. However good future prospects may be, in Eastern countries the higher class native will

not do manual work, and so will not pass through preliminary training as a fireman. The two grades will have to be kept entirely separate, and apprentices should be enrolled for training as engine drivers, in the same way as apprentices are trained for fitters, and when vacancies occur for shunting drivers, they should be filled by apprentice drivers who are up to the required standard.

The coal used is obtained from the colliery at Enugu as previously mentioned. The charge made is 10*s.* per ton on the Eastern, and 28*s.* per ton on the Western line. The calorific value, 11,290 B.Th.U., is somewhat low, but it is remarkably cheap and despite the waste in carriage and difficulty of complete combustion, the railway is extremely fortunate in having such a cheap regular supply close at hand. The consumption varies from 72 lb. to 92 lb. per engine mile, but when new fire bars and brick arches are fitted, it is hoped to reduce this figure to 65 lb. The inspection of boilers is stated to be thorough and the records well kept. Except on the Eastern line, the water is good, and there has been remarkable freedom from boiler trouble. The good quality of the water led some while ago to the adoption of steel tubes on the Western line, but these have not proved satisfactory on the Eastern line, and are being replaced by brass or alloy tubes.

With regard to the rolling-stock, all vehicles are subjected to three-monthly examinations. Bodies are lifted, the bogies examined, and boxes repacked, the date being stencilled on the vehicle. The hot box returns for the past three years show an average of about 100 per annum, which is not high. Attention is drawn to several failures of the automatic brake with which the vehicles are fitted, and cases are quoted where on the train parting, the rear portion has run a long distance before being pulled up.

In addition to its ordinary duties in connection with the maintenance of way and works, the engineering department has under its charge several large works paid for out of capital funds. These include the relaying of the section from Iddo to Ibadan, the construction under contract of the workshops at Ebute Metta and Enugu, and the survey for the realignment between Minna and Kaduna. The staff for these duties is separate from the ordinary maintenance staff.

Lieut.-Colonel Hammond calls attention to the size of the districts of the maintenance staff, which even after the completion of the Eastern line, and the branch to Bauchi Plateau, and adjustments made, will average 267 miles each. European foreman platelayers are employed in charge of maintenance of the track, only one native foreman platelayer being employed. It is recommended that a larger number of native foremen platelayers should be employed, the European foremen being reserved for special work, such as the laying out of points and crossings, and it is suggested that three or four native foremen should be placed under one European. The report gives interesting notes on the use by European foremen of motor trollies with the idea of increasing their radius of work, but the trollies proved heavier than intended and despite the increased speed, the men could not have given the same attention to the road as they did without such machines. Even travelling slowly for a motor vehicle the speed would still have been too fast to enable the track to be examined as closely as it should be, and there is always the temptation to travel at the higher speed.

Several stations between Ibadan and Jebba have loops much shorter than the standard length of 1,400 ft. in the clear, some are as short as 774 ft. Trains containing many empties are often longer than 900 ft., if a crossing has to be effected with one of these trains at a station with a short loop, much shunting and loss of time to pass is involved.

The railway is fed at certain points by motor transport run by the railway, but as there is now so much private competition, and the types of lorries are not suitable for the purpose required, Lieut.-Colonel Hammond recommends that these services be cut down to the Bukuru service only; the remainder of the lorries should be sold together with their spare parts.

THE INSTITUTION OF MECHANICAL ENGINEERS.

An ordinary general meeting of the Institution of Mechanical Engineers was held on Friday last, April 24, at the Institution, Storey's-gate, Westminster, when the President, Sir Vincent L. Raven, occupied the chair.

Hardness Tests Research.

Two papers on Hardness Tests Research were presented in abstract by their respective authors and were then discussed. These contributions were: "Report on the Effects of Adhesion between the Indenting Tool and the Material in Ball and Cone Indentation Hardness Tests," by Mr. G. A. Hankins, of the National Physical Laboratory and "Some Practical Aspects of the Scratch Test for Hardness" by Mr. Geoffrey A. Shires. Both are reprinted, abridged, in this issue of Engineering, and will be found on pages 556 and 557.

Dr. W. Cawthorne Unwin opened the discussion. He remarked that the paper by Mr. Hankins contained a great deal of new information, and one of the ideas brought forward cleared up a number of doubts and difficulties. Indentation hardness had been taken as the load on the tool divided by the area of the indentation. The author had shown that part of the load was supported by the frictional adhesion between the tool and material and took no part in making the indentation, so that the proper rule should be, the load minus the friction divided by the area of the indentation. With regard to area, Brinell divided the load by the spherical area of the indentation. Ludwig divided the load by the conical area of the indentation. Six and a-half years ago he (Dr. Unwin), (see Engineering, vol. cvi, page 478), had indicated as a general principle, without any experiment, that in indentation tests, it was not the spherical or conical area that should be taken, but the projected area, and he had said that if that were done, the hardness number for the ball test should agree with that for the cone test. He had not been altogether right in that contention. He had not at that time known of the influence of friction, and it was not until they used Mr. Hankins' method of first detecting and allowing for the friction that the conditions he cited were satisfied. Taking the hardness number as the difference of the load and the friction, divided by the projected area of the indentation, the ball hardness and cone hardness numbers should agree. Certain experiments were made by Mr. Batson, at the National Physical Laboratory in 1918, which seemed to show that he (Dr. Unwin) was wrong. When the necessary frictional allowances were made, Mr. Batson's results were found to agree with his original contention. In Table XVII of Mr. Hankins' paper (see page 556) there was an extensive comparison of the author's own results, and from this it would be noted that for any given indenting tool the hardness number was the same over a considerable range of loading, and for both ball and cone tests. It was, therefore, impossible not to see that the new value of the hardness number shown by Mr. Hankins must be a truer value of the hardness than the number as ordinarily calculated. The author of this paper had also found that, in certain cases, lubrication of the indenting tool made a difference in the size of the indentation. Lubricating a tool merely meant reducing the friction. A curious point arose. In the case of the ball test, when calculated as Brinell would have done (by dividing by the spherical area), there was not much difference when the ball was lubricated. That was of practical importance because it showed that it was needless to make much alteration in the method of the Brinell test.

Continuing, Dr. Unwin said that it was almost a fetish among hardness testers to affirm that in making a ball test the load should be proportional to the square of the diameter of the ball. Mr. Hankins' tests, however, showed that, to make proper hardness tests with balls, the load must exceed a certain minimum limit, below which false numbers would be obtained. If the pressure of fluidity of the metal were not reached at the contact surfaces, the full hardness would not be brought out. Mr. Hankins' experiments also showed that, for any given indenting tool, over a considerable range of load, very nearly the same hardness number would be obtained, if corrections were made for friction, as if the hardness number were calculated in the ordinary way. He had, in 1918, called attention to the advantages of using a cone instead of a ball in making hardness tests; these advantages he would like to reiterate. He would say that, first of all, the hardness number in the case of the cone test was constant over a greater range of loading than in the ball test. The cone test also afforded a very easy method of determining the co-efficient of friction. Again, the formula for hardness in the cone test, when friction was allowed for, was quite simple, and was even less complicated than the ordinary Brinell formula. There was yet another point. Possibly it would be easier, in a cone test, to use a black diamond or an artificial sapphire as the indenting tool. This would be more easily ground to the cone shape than to a ball, while it was also possible that the hard materials at present difficult to test could, in this way, be more easily tested. Another important point in Mr. Hankins' paper referred to exceptional materials, particularly manganese steel, the behaviour of which was peculiar. In the case of viscous manganese steel the load should, possibly, be applied, not for the usual 30 seconds, but perhaps for 24 hours, before the definite value of the indentation could be fixed. The point was important, because hardness tests should not be extended to all kinds of materials without care.

Professor B. P. Haigh observed that one of the features of the Brinell test was that attention was fixed on the diameter of the indentation, no other information being required in practice. For research purposes, however, much was to be gained by looking further afield. On examining the metal surrounding the cup of the indentation, it would be found that different metals gave different shapes. It followed that the stresses acting in the metal must be completely different. What was the nature, he asked, of the stresses round about the surface? At the bottom, of course, there was pressure and no considerable friction. At the outside there would be much less pressure and, as careful consideration showed, a great deal of friction. There was no reason why the deformation of the metal should be left out of consideration because it was due to frictional forces. He could not, therefore, accept the view put forward that the friction was a thing to be eliminated from calculation, but that friction ought to be regulated, if possible, so that it acted in the same way in different tests. Friction was not a non-essential part of the Brinell test and there was no justification in trying to eliminate it. He had endeavoured to regularise friction in experiments such as those described by Mr. Hankins, and he had been astonished at the difficulty in finding any difference between different lubricants. In the Brinell test he had only used a 5 mm. diameter ball, and not the larger sizes, but it had been very difficult to find a variation of more than ½ per cent. The only example of a wider variation was an instance in which plain yellow soap was used as a lubricant, and in that case the difference was 5 per cent. With the prism test there was much less slipping.

Dr. Walter Rosenhain, referring to the effect of lubrication on indentation, said that a matter requiring attention was the time allowed for the lubricant to escape, particularly in the cases in which Mr. Hankins made an impression, covered it with lubricant, and then re-inserted his indenting tools and redetermined the result. Much would depend, he thought, not upon the time during which the load was applied, but upon the rate of increase of load. As Dr. Unwin had pointed out, there was an easy escape for the lubricant, but he felt it right to say that given time enough the lubricant would be squeezed out completely, except for the boundary layer in the cone test. Sir William Hardy found that by merely allowing a weight to rest on a flat plate lubricant—if given time enough—would be entirely squeezed out. Therefore the rate of indentation would be likely to have an effect; not, of course, large, as the total effect of friction did not appear to be large. The friction between the two surfaces was not only a function of the lubricant but also of the nature of

the surfaces themselves. Mr. Hankins had recognised that, but had found that the difference was not very large. He had, no doubt, finished the surface of his indenting tool very perfectly, and that might make a considerable difference. The use of a cone which was extremely smooth and hard might render the difference of friction between different materials smaller than if a rougher cone were used.

From the theoretical point of view, one point impressed him, namely, the fact that cones of different angle, when the corrections were applied, gave identical contact pressures. He was a little surprised at that, as the amount of cold work which the material received must have been different when using a 120 deg. cone and when using a 30 deg. cone. The key could, perhaps, be found in the fact that the flow pressure of the metal at the surface had to be exceeded, in any case, before a satisfactory result could be obtained. The general fact remained that there was a deformation in a fairly large zone of metal, and the amount of deformation would depend on the quality of the metal—whether it was previously hard worked or not. If that were all, a constant value for the contact pressure, with cones of different indenting angle, would not be expected, simply because the amount of deformation of the surrounding metal must be very different when using a sharp cone or a blunt one; that it was not found was surprising and required explanation. It led to some speculation as to whether there might not be some factor not yet taken account of, but which might explain the small apparent effect of friction. The behaviour of manganese steel seemed to bear on the point; manganese steel underwent a remarkable degree of hardening as a result of deformation. He did not think that time entered into the consideration so much as Dr. Unwin suggested. Evidently, in manganese steel the effects of cold work were sufficiently marked to make themselves felt, whereas in the other materials used by Mr. Hankins that effect was not so marked.

Turning to the subject of the scratching test, the objections to its use were great. If it were necessary to use so delicate a measuring instrument as that described in Mr. Shires' paper, the test was not one which could be regarded as satisfactory. There were, however, points about the test which rendered it attractive, particularly the possible application of it to materials of very high hardness. The author had tried to scratch glass with his diamond, and after a little scratching the diamond had begun to show signs of great wear and tear. He assumed therefore that the diamond which Mr. Shires used was not applied in the right way for scratching and cutting a very hard material. There was a great deal to be learnt from the diamond setter. When attempts were made to use the diamond for scratching the surfaces of very hard substances, such as hardened steel, the diamond might behave in some way analogous to its behaviour on glass. There would be two different ways in which it might act; one would be to scratch and the other to cut. From careful observations of scratches on glass, he could say that the diamond might stagger or chatter; instead of having a uniform smooth slicing action, it might jump up and dig in again with brief periodicity. Similar action might result when passing a diamond over hardened steel. He therefore suggested that, in the softer as well as the harder materials, it might be worth while to use deeper scratches and decidedly heavier loads, thereby avoiding the necessity for excessively delicate measurement. The sclerometer which Mr. Shires described made no provision for the angular setting of the diamond. Accurate setting of the diamond and the use of a very much heavier load would make it possible to obtain scratches of sufficient depth and width to be easily measured without excessive readjustment; and it might be possible, by using the diamond at the proper angle, not necessarily in a vertical holder, to secure on hardened steel one type of indication; not one type at one time and another later on. The scratch method measured surface hardness, whereas an indentation measured something else, which had a factor of strength about it. Consequently discrepancies were apt to arise, and it was necessary to look to their origin.

Dr. Harold Moore, referring to Mr. Hankins' paper, expressed surprise at the statement that the condition found with a vaseline coating was "presumably a usual condition in most indentation tests." In his experience, Brinell impressions were frequently made on surfaces which were particularly free from lubricant, although he did not say they were free from it altogether. Frequently, too, the ball was cleaned with petrol or something of that kind. He had made enquiries and was told that lubrication was not commonly used in Brinell hardness tests. He thought that Mr. Hankins had definitely shown that adhesion or friction did exist. A similar effect was well known in the compression test. Some time ago he had occasion to investigate this with some care in a test on a cylinder of annealed copper. There were two conditions for comparison. In the first case, the cylinder was compressed between highly polished, very hard and lubricated steel faces. In the other case, the copper was compressed, without lubrication, between intentionally and minutely roughened dry steel plates. In the perfectly lubricated case, the test piece remained parallel. In the other case, it was found that, in compression between the roughened faces, the specimen became deformed. The point he wanted to make was that in the one case the friction or adhesion effect was, apparently, entirely eliminated by taking smooth and perfectly lubricated faces, and that the effect on the dimensions of the test piece was not very great. Mr. Hankins had certainly shown that the adhesion effect existed in the cone and the ball tests. He questioned, however, the magnitude of that effect, which he felt was much exaggerated in the paper. Mr. Hankins' method of arriving at μ was to use cones of different angles and assume that the difference in the contact pressure given by the two cones was due to adhesion solely, and on that assumption he had calculated μ, the coefficient of adhesion. That appeared rather unsound, in view of Dr. Rosenhain's reference to the very different character of the deformation produced by cones of different angles. Mr. Hankins had explained his calculation by saying that μ calculated from cones of two different angles would apply, apparently, to cones of any angle. Comparing a 45 deg. cone with a 90 deg. cone, in view of the amount of material displaced and the amount of cold work on the test piece, it seemed extremely unlikely that the same corrected contact pressure could be obtained by the correction for the friction only. He therefore suggested that more confirmation was desirable before the conclusion was accepted and practical hardness tests were based on it. Confirmation was needed of the actual value of μ before the figure 0·425 could be accepted.

Mr. P. V. Vernon had entertained a fear that the Brinell test, so useful to engineers, was in danger, but the moderation shown by the authors, when presenting the papers, had largely removed his apprehension. This test could be easily and quickly made. He was not quite convinced about the views expressed with regard to friction. It appeared to him conceivable that the particles with which the ball or cone made contact might move down into the material, causing an internal deformation. The real friction taking place was not friction from the impression sliding on the surface of the ball or cone, but internal friction among the particles of the material itself. He noticed that, in making his tests, Mr. Hankins had used a Buckton single-lever machine. He, Mr. Vernon, had tried to make reliable hardness tests with a single-lever machine without success. Some doubt must be thrown on results obtained by that method, as the inertia of the beam rendered it difficult to get uniform results when repeating tests on the same material. The use of a single-lever machine also created difficulty in making impressions in uniform time. The interesting fact emerged from the results of some of his own tests, that the time of application was much more important than duration. Naturally, in making tests, it was desirable to make as many as possible per hour, and since there was an advantage in slowing down the rate of application it was desirable to shorten the duration.

Mr. T. W. Cooper thought that the value of the scratch test had been clearly emphasised in one of the papers. In his own business, uniform hardness of the materials was of paramount importance, and, in testing for this, every known means of hardness testing had been resorted to, but for years past he had adopted the scratch test. He did not urge the scratch method for all materials, and was alive to the value of the Brinell test. For small sections, however, he had abandoned the Brinell method and taken to the Rockwell. Table I of Mr. Shires' paper (see page 557) drew attention to the great difference in the Brinell hardness numbers as compared with width of scratch. He, Mr. Cooper, had also found the reverse results—pronounced differences in hardness as indicated by the scratch test, and very small differences in the Brinell or Rockwell tests. With materials of exactly the same analysis and with the same Brinell number, there was a marked difference in the machining properties. He did not know whether the two authors had discovered anything along those lines, but it would be interesting if they could compare notes in that regard. There was a great need in industry for a machine which would give a hardness reading without deformation of the surface. In testing for surface hardness, it was essential that the whole of the hardened surface should be tested, and to make an impression constituted a blemish which might cause the rejection of the actual specimen tested.

Mr. R. G. C. Batson followed, and stated that Mr. Hankins would agree that the adhesion method was not the last word in hardness testing. Mr. Hankins had said that the results showed no adequate reason why, in the case of the majority of materials, any alteration in the Brinell test should be made—or in the method of expressing the results—and that it would be generally agreed that the Brinell method would remain until it was possible to obtain another hardness scale which could be as easily and readily applied. At the same time, it was well known that the sooner the empirical hardness scale gave place to an experimental one, the better. The empirical nature of the Brinell test introduced many pitfalls, one of which was clearly shown from analyses of some of the results in the paper. Considering Mr. Hankins' tests of annealed copper and of rolled copper, it would be found that one experimenter would test, under more or less standard conditions, up to 500 kg. with a 10-mm. ball, and would obtain a value for the annealed copper of about 40, and for the rolled copper of about 70. Another experimenter would, perhaps, adopt his own standard and would test the same materials up to 2,000 kg., obtaining a value of 48 for the annealed copper in place of 40, while for the rolled copper he would obtain approximately the same value. Therefore, one of the experimenters would get a wrong idea as to the relative hardness of the two materials. With regard to scratch hardness, Mr. Shires' paper appeared to show this test in a rather poor light. The author definitely stated that it was not suitable for workshops, implying by that statement that it was only suitable for people who had had considerable experience with such instruments. Yet he had told the meeting that he would like to see the instruments made in mass production, which was not quite consistent.

Mr. H. S. Rowell thought that Mr. Hankins had looked on hardness tests as though the actions used were comparable with a wedge splitting a log of wood, whereas it would probably be much better to look at the hardness test as the splash of a ball falling into a very dense and viscous liquid. Professor Worthington, some years ago, made some studies of splashes arising from steel balls falling into mercury, and the craters round the point of impact had been very similar, in many cases, to the craters of Brinell impressions. In the more interesting part of Mr. Hankins' paper, it seemed to him that the thesis depended on the existence of friction at the surface between the ball and the steel under test. If that friction were the basis of the theory, it should tally with friction experiments carried out under other conditions. That was the crux of the entire subject, and although that theory might give an approximate expression for the viscous flow in the metal, he thought it could not be expressed too clearly that it did not

give any relation whatever for the friction at the surface of the ball on the steel.

The President having proposed a vote of thanks to the authors. Mr. Hankins acknowledged this and said that Mr. Vernon need be under no fear in regard to the testing machine; he was sure that the results obtained were perfectly satisfactory.

The proceedings were then closed, the announcement being made that on Friday, May 8, there would be an extra general meeting at 6 p.m., when the Fourth Report of the Steam Nozzles Research Committee would be presented.

LABOUR NOTES.

A SUMMARY of the proposals, relating to working hours and wages, which the Engineering and Allied Employers' National Federation have submitted for the consideration of the engineering trade unions, was given in our issue of last week. The text of the offer is as follows:—

1. Dayshift: 50 hours, at present hourly rates for 47 hour week (excluding war bonus).

2. Nightshift: 52½ hours.

3. War Bonus: 2*s.* per week to be added in the case of those classes entitled to the 10*s.* war bonus. In view of the special bonus of 2*s.* 9*d.* at present paid in Belfast, this additional bonus of 2*s.* shall not apply to Belfast. The 12*s.* bonus in respect of the 50 hours dayshift week and the 52½ hours nightshift week shall be *pro rata* for shortened or lengthened week, but shall not be subject to overtime, nightshift or payment by result percentages. The 2*s.* bonus will be granted as to 1*s.* when the proposal is agreed and 1*s.* six months later.

4. Nightshift Payment: Where overtime and nightshift agreement applies, time and quarter.

5. Overtime Payment: Where overtime and nightshift agreement applies:—*On dayshift*, time and quarter first two hours and time and half thereafter, in any one day. *On nightshift*—time and half.

An explanation of the proposals is appended:—

1. Dayshift: This means a week of 50 hours paid for at the present dayshift base hourly rate multiplied by 50 (say at 47*s.* per week = 50*s.*) to which a bonus of 12*s.* would be added for a full week or proportionately more or less in accordance with the number of hours worked.

2. Nightshift: 52½ hours at present base hourly rates (52*s.* 6*d.* as above) plus one-quarter of this sum as explained in (4) below, plus 12*s.* bonus for full 52½ hours or proportionately in accordance with hours worked.

3. War Bonus: It is to be specially noted that the bonus enhanced as proposed is to apply only to those classes who are in receipt of the present war bonus of 10*s.* The bonus enhanced as proposed is 12*s.* per week, applied as shown in (1) and (2) above. No portion of this bonus is to be taken into account in assessing the allowances due for overtime, nightshift, or payment by result percentages. At present the war bonus is taken into account for calculating the allowances for overtime and nightshift.

4. Nightshift Payment: Applies only where the overtime and nightshift agreement now applies. The present allowance is one-third calculated on the dayshift base rate plus the war bonus. The proposal allows only one-quarter extra of the dayshift base rate alone, excluding the enhanced bonus.

5. Overtime Payment: Applies only where the overtime and nightshift agreement now applies. *On dayshift*—The allowance now proposed is one-quarter for first two hours' overtime daily, calculated on the base rate only. At present an extra of one-half is given, calculated on dayshift base rate plus the war bonus. After first two hours an extra of one-half calculated on dayshift base rate excluding the enhanced bonus. No double time is to be paid after midnight as at present. *On nightshift*—The allowance now proposed is one-half calculated on dayshift base rate, excluding the enhanced bonus instead of two-thirds calculated on dayshift base rate plus war bonus as at present.

In a letter sent to the trade unions with the proposals Mr. James Brown, Secretary of the Engineering and Allied Employers National Federation said:—

"Since the joint meeting of the sub-committees of the Federation and the unions on March 31, 1925, the position of the industry has been the subject of very anxious consideration by the employers. A review of the situation which has developed during the last twelve months, and especially since the beginning of this year, has impressed the employers with the outstanding fact that the engineering industry of this country has reached a crisis which, if it is to be overcome, will only be overcome by the fullest co-operation of all concerned. That a crisis exists cannot be doubted by anyone conversant with the facts.

"When we met in sub-committee on March 31, your chairman urged that the employers should state the amount of the advance in wages they were prepared to offer and the conditions attached thereto. The employers were at that time, for the reasons explained, unable to do so. Since then, the whole position has been reviewed by the Federation, and in the light of recent developments, it has been decided that in order to clarify the issue at the forthcoming meeting of the unions, a definite proposal should be submitted. I am accordingly desired to append the proposal.

"In submitting this proposal I am desired to direct the attention of the representatives of the unions to the following considerations:—(*a*) The position and prospects of the industry are worse than they were at the beginning of this year. (*b*) The critical position demands a remedy of a drastic character. (*c*) The increase in the length of the working week at this stage is rendered necessary by the action of our foreign competitors who maintain a working week extending to 60 hours at lower rates of wages and working conditions and temporarily render competition by this country in the world's markets so difficult. (*d*) If foreign competitor nations effectively decrease their working hours so as to bring them into reasonable relation to the working week in this country, the arrangement now proposed could be reviewed. (*e*) Meantime it is suggested that a joint submission by the Federation and the unions should be made to the Government, pressing upon them the necessity of taking such steps as may be possible under the Peace Treaty or otherwise to secure an arrangement whereby the working hours of competitor nations on the Continent should be dealt with as indicated. (*f*) An increase of hours to meet the necessity of the case has already a precedent. (*g*) The extension of hours and the bonus proposed will substantially increase the earning power of the workpeople. (*h*) The readjustment of the cost of nightshift will, if trade improves, give substantial employment to those unemployed. (*i*) The employers feel sure that the gravity of the situation will convince everyone concerned of the necessity of increasing production and reducing costs. (*j*) One of the serious and avoidable causes of high cost of production is restriction of output. Elimination of this would be a powerful stimulus to reduction of costs, revival in trade and increased employment. Important also is the relaxation of the claim of any class of workpeople to an exclusive right to any operations or any particular job. Co-operation by the trade unions in these directions is essential from a national as well as an industrial standpoint. (*k*) It is to be kept in view that the 10*s.* war bonus is still in operation.

"Should your sub-committee desire to have explanation of any of the provisions of the proposal, the Federation will be glad to arrange an early meeting for this purpose. Meantime I am desired to suggest that the proposal should be considered with due regard to the vital necessities of the industry."

The conference of engineering trade union representatives to which these proposals and the accompanying letter were submitted, decided to refer the matter to their various executive councils, and to meet again in London on May 20. The offer was officially stated to have "somewhat surprised" the delegates, and "strong opinions were expressed at the attitude of the employers in submitting" it. On reflection, however, it was realised by individuals (1) that there was nothing really surprising in it, and (2) that, considering what the need of the British engineering industry is, no alternative course was open to the employers. In the country the proposals have naturally not been received with great favour. Well-known extremists here and there have, as a matter of fact, strongly condemned them. The feeling amongst moderate men is, however, that they cannot be ignored, but, on the contrary, must be carefully studied. If they are given full effect, production costs will be reduced to a level which will enable the industry to cope with foreign competition, every day-worker will be able to earn more money per week, and the community's heavy burden of unemployment will be lightened. The employers' aim is to achieve these objects, and they will welcome the co-operation of the workers' representatives.

The shipyard trade unions and the Shipbuilding Employers' Federation have agreed to set up a joint committee to carry out an investigation into the economic state of their industry. The scope of the inquiry will, it is understood, be fixed at a joint meeting of representatives of both sides in London to-day, and the smaller body will begin its work within the next few days. The scope of the investigation should not be difficult to arrange, as no practical shipbuilder or shipyard worker is in any doubt as to what is the matter with the industry. The theorists who abound in the Labour movement to-day can, of course, make difficulties if they choose. It is to be hoped, however, that, remembering the state of the industry, and its high unemployment figure, they will, for once in a while, forget their peculiar economic theories, and deal like practical men with the facts of the matter. The position here, as in engineering, calls for business-like treatment.

At a meeting in London last week, the executive of the Miners' Federation of Great Britain decided to hold a delegate conference at Blackpool on May 20 "to hear a report of the proceedings of the joint committee up-to-date and to discuss the whole situation." Another meeting of the joint committee of coal-owners and miners' representatives is to be held in London a week before the delegate meeting, and at it, it is understood, the coal-owners will be invited once again to bring matters to an issue by putting forward definite proposals. A majority of the men's executive wish to have the joint inquiry concluded, and the employers' proposals formulated before the delegate conference takes place.

The Court of Inquiry into the Labour troubles which are threatened over the construction of Messrs. G. and J. Weir's steel houses has reported much as reasonable men on both sides expected it would. "There appears to us," it says, "to be no reason why the local authorities should not proceed at once with their arrangements for the erection of the demonstration Weir houses. It is very desirable in the interests of the community that the recommendations of the Moir Committee for the erection of houses of a type faced externally with steel sheeting in sufficient numbers to enable the system to be properly tested, should be carried out at the earliest moment. The question of the rates of pay which should be assigned to the different classes of workmen engaged in the various operations in the housing factory and upon the sites, and the conditions of their employment, is, in our judgment, a matter which ought to be, and can be, settled by agreement between Messrs. Weir and the trade unions representing the men employed on the work; rates and conditions thus determined would appear to us to meet the obligations imposed in connection with the observance of the Fair Wages Clause. It is not, in our view, a case for the automatic and rigid application of rates and conditions which have been established in respect of the ordinary methods of the building trade. The erection of the Weir house consists of the assembly of a number of standardised parts carefully prepared in advance in such a way that they will fit together without adjustment and without requiring the skill of specialised craftsmen. The representative of the National Federation of Building Trades Operatives gave us a vivid description of the method of building the ordinary brick house. The process as described appears to us to be essentially different from that involved in the assembly of the Weir house. Furthermore, there can be no doubt that payment by results—a recognised feature in the engineering industry—is peculiarly appropriate to the methods both of manufacture and assembly followed by Messrs. Weir in house construction, and we are convinced that such a system, worked out in conjunction with the men's trade unions, will, if put into operation by Messrs. Weir, result in advantage both to the firm and to the men employed. . . . It appears to us, therefore, that both rates of pay and conditions of labour must be adjusted to the new conditions by the procedure we have suggested above. The position of the workmen employed can, in our opinion, be fully safeguarded by their own trade unions, in consultation on matters in which the interests of the building trade proper appear to be affected with the building trade unions."

The National Federation of Building Trades Operatives naturally strongly dissent from the findings of the Court. At the end of a long statement, signed by Mr. Coppock, appears this paragraph:—

"We stand for the maintenance of collective bargaining, the retention of the fair wage resolutions throughout the country, and for the standard building trade rate to be paid to any person who may be employed in erecting any type of house, whether it be 'Weir,' 'Athol,' 'Wild,' 'Telford,' brick, stone or concrete. Our stand is made in the interests of the trade-union movement, and no amount of sentiment can upset our just claim."

The Ministry of Labour states that on April 20, 1925, the number of unemployed persons on the registers of Employment Exchanges in Great Britain was 1,202,700, viz., 922,300 men, 36,600 boys, 211,600 women, and 32,200 girls. On April 13, 1925, the number was 1,204,770, made up of 924,810 men, 33,564 boys, 216,351 women, and 30,045 girls; on April 21, 1924, it was 1,050,546 or 775,632 men, 32,362 boys, 210,191 women, and 32,361 girls.

PULLING JACK FOR MINE WORK.

CONSTRUCTED BY MESSRS. HADFIELDS LTD., ENGINEERS, SHEFFIELD.

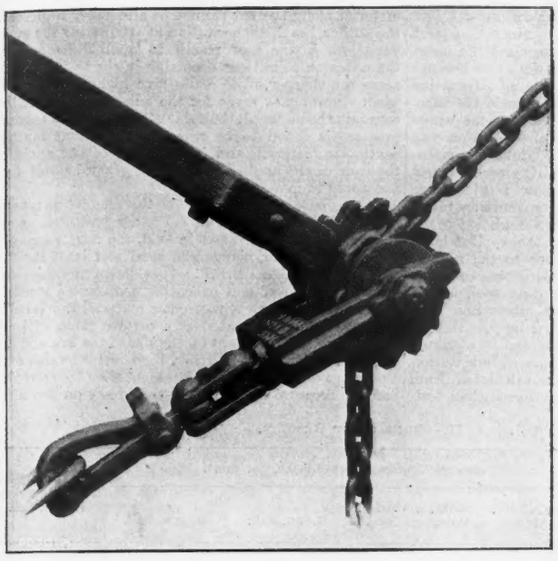

FIG. 1.

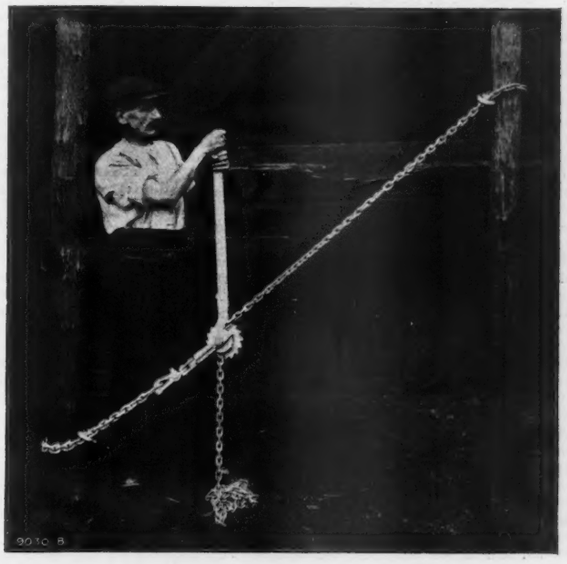

FIG. 2.

FIG. 3.

FIG. 4.

THE HECLA PULLING JACK.

WHEN the coal has been removed from the working faces in any place in a mine the props supporting the roof are usually withdrawn and the roofs are allowed to settle down on gobs, or packings made up of waste material. Not only are the good props saved by this process and made available for use in other locations, but the roofs generally settle down on the gobs much more steadily and regularly than if any of the props were left behind. Careful withdrawal of the timbers is advisable, in order to reduce to as small a number as possible the accidents to miners at their working places, due to excessive pressures suddenly causing a collapse. Various devices have been designed to obtain the necessary pulls to withdraw the props, but many of the appliances, until now available, cannot be employed unless there is plenty of space available, which is, unfortunately, not a common condition in a mine. Recently a practical miner, Mr. W. Blair, devised a pulling jack for the purpose which is suitable for use in restricted spaces and has many interesting features and applications. This appliance, the manufacture of which has been taken up by Messrs. Hadfields Ltd., of Hecla Works, Sheffield, is illustrated in Figs. 1 to 4 above.

It consists of a chain-pulley winch, operated by means of a rachet drive, and is provided with a hook for connection to a lashing chain. All the parts are made from Hadfields' toughened or forged steel. The simplicity of the device and its compactness will be apparent from Fig. 1, which shows the complete equipment with pulling chain, and its application to three types of work may be seen in Figs. 2 to 4. The method of use consists in attaching the pulling jack by its lashing chain to a suitable prop and tying the end of the pulling chain to the prop that is to be withdrawn. The free part of the pulling chain can now be set on the chain wheel to leave little slack in it. Once this is done and the links of the chain are lying snugly in the pockets of the chain wheel, the prop can be removed by exerting a suitable pull on the chain by working the lever to and fro. The withdrawal of a prop by using a direct pull from the jack is shown in Fig. 2, while the introduction of a twisting movement prior to the direct pull, by the introduction of Alcock's "Twista," is depicted in Fig. 3. Buried props can be recovered by the use of the appliance, and Fig. 4 affords an indication of how the device can be applied to the exposed part of a sunken prop for the purpose. In addition to these classes of work, it will be obvious that a pulling jack of this type may be used for other types of work, such as releasing buried rails and wagons, drawing the ends of wire ropes together for splicing, separating loaded wagons that have become interlocked and for moving heavy weights generally. It will be recognised that for almost every purpose the work can be performed at one setting of the pulling jack, and thus the wasted time due to slacking off and taking up the chain, which is necessary with some types of jacks, is avoided.

U.S. OIL REFINERY STATISTICS.—The daily capacity of the petroleum refineries of the United States, including those building, is 2,832,532 barrels of oil. This figure shows an increase of nearly 138 per cent. in refining capacity within the past seven years. There are at present 547 oil refineries in the United States compared with 176 on January 1, 1914.

HARDNESS TESTS RESEARCH.

*Report on the Effects of Adhesion between the Indenting Tool and the Material in Ball and Cone Indentation Hardness Tests.**

By G. A. HANKINS, A.R.C.Sc.

THE Report contains the results of experiments which have been made with the object of supplementing existing knowledge on the results given by static ball or cone indentation hardness tests when adhesion between the indenting tool and the material is considered. The work was commenced with the intention of investigating the relation between the results given by the scratch method devised by the Author (see Proceedings I.Mech.E., 1923, page 423) and the normal ball and cone indentations. In certain tests which were made in order to compare the mean pressure under the diamond point in a scratch test with the mean pressures under the indenting tool in a ball or cone test, indications were obtained that some form of adhesion, analogous to friction, between the indenting tool and the material was of appreciable importance when accurate mean pressures were required. There were also indications that the adhesion was dependent, to a limited extent, on the initial conditions of the surface of the indenting tool and the material with regard to lubricant, and that variations in static indentation hardness test results might occur by reason of variations in the initial surface conditions.

The Ludwig cone hardness test,† in which a 90 deg. steel cone is used as the indenting tool, has not been widely used in this country, but for convenience in the preparation of the initial conditions this form of test was preferred to the ball test. It has been stated that indications were obtained that variations in the hardness number might occur by reason of variations in the initial surface conditions of the indenting tool and the material, and in the first tests that were carried out, widely dissimilar conditions were produced in order to increase any possible variations in the resulting hardness numbers. The variations in initial conditions were obtained by carefully cleaning the cone and the surface of the bar before each test, and then applying a small quantity of a particular lubricant immediately before the actual indentation was made. One test was also made without any lubricant on the cone and surface. It was found that the initial conditions of the surfaces had an appreciable effect on the sizes of the impressions produced, and, as would be expected, the good lubricant, oleic acid, gave the largest, and clean conditions the smallest, indentation. Vaseline gave an intermediate result. It was inferred from these tests that an action similar to static friction, but probably approaching boundary conditions, was instrumental in supporting a portion of the load in the cone tests. The results show that variations of initial conditions which may arise in practice are liable to cause appreciable variations in the resulting hardness numbers. Subsequent experiments were made on various materials, and it was found that unless similar initial conditions were used, variations in the size of the resulting impressions were liable to occur. It was found, however, that when vaseline was used on the cone and surface, fairly consistent results were obtained.

The wide variations in results that can be obtained by variations in the conditions of lubrication of the cone show, fairly definitely, the existence of the adhesion, and that it is an important factor in the results obtained. It should be noted, however, that the results were fairly consistent in the cases in which separate impressions were made on a material under definite initial conditions, and that the value of the $\frac{\text{Load}}{\text{projected area of impression}}$ was independent of the applied load. For various reasons it was decided to prepare hardened steel cones with vertical angles of 120 deg., 60 deg., and 45 deg., and to carry out tests with them on different materials. In making these tests it was found that the inconsistencies noted with the 90 deg. cone were considerably less with the 120 deg. cone, but were accentuated in the cases of the 60 deg. cone and the 45 deg. cone. With the latter, considerable care in maintaining constant initial conditions was necessary in order to obtain consistent results.

Miscellaneous ball indentation tests were made on copper, mild steel, and 0·48 per cent. carbon steel using 5 mm. and 10 mm. steel balls at the standard loads of 750 kg. and 3,000 kg. respectively. It was found that wide variations of initial conditions had no appreciable effect on the diameters of the impressions produced, and it was concluded that variations likely to occur in routine ball hardness testing due to variations in initial surface conditions, were so small that they could be neglected. It should be noted that it was found to be difficult to clean the balls used for the tests, and it seems probable that a thin film of grease remained on the surfaces of the balls, and this may account for the constant result obtained in ball tests under various initial conditions. The results showed that the adhesion exists in the normal ball indentation test, and, as would be expected, the effect is greater in the deeper impressions.

The method of expressing an indentation test result in terms of a stress or pressure gives the mean stress per unit area over the indentation, and because of the unknown distribution there was no alternative to making the correction for the adhesion in the same way on the mean stress per unit area over the whole indentation. The assumption that the adhesion was similar to static friction when equilibrium was maintained between the applied load and the resistance of the material can be expressed as follows: (*a*) A force similar to a frictional force, acted tangentially along the surface of the indenting tool over the whole surface of the indentation in opposition to the applied load. (*b*) The ratio of the tangential force to the normal pressure between the tool and the material was constant for a polished hardened steel indenting tool, and a given test material under constant lubrication conditions. This ratio has been denoted by μ. Making the above assumptions, an expression can be obtained by means of which the mean resistance to indentation corrected for the adhesion can be calculated from the diameter of the indentation measured after test, provided a value of μ can be obtained and that elastic deformation can be neglected. In expressing the result when such a correction had been applied, it was desired to obtain a measure of the mean intensity of pressure between the indenting tool and the material, in preference to a more or less arbitrary hardness number. In order to do this it was necessary to depart from the usual method of expressing results. It has been pointed out by Dr. Unwin (see Proceedings M.I.Mech.E., 1918, p. 486) that it is more logical to express indentation hardness results as $\frac{\text{Load}}{\text{projected area of indentation}}$, in preference to $\frac{\text{Load}}{\text{spherical area of indentation}}$, although the latter method is usual in ball and cone tests. From considerations of equilibrium the latter is not correct. It is also well known that measurements of depths of indentations neglect ridge formation round the indenting tool, and since the inner part of the ridge helps to support the applied load, it is incorrect to neglect it. Hence, in the present experiments, the adhesion correction has been based on $\frac{\text{Load}}{\text{projected area of indentation}}$, and diameter measurements have been used. It was found that the corrected mean normal pressure between cone and material, p, was given by the following expression

$$p = \frac{P}{\pi r^2 (1 + \mu \cot \theta)}$$

where P = the applied load, $r = \frac{1}{2}$ (diameter of indentation) and $\theta = \frac{1}{2}$ angle of the cone. The similar equation for a ball indentation is

$$p = \frac{P}{\pi r^2 + \pi R^2 \mu (\theta - \sin \theta \cos \theta)}$$

where R is the radius of the ball and $\theta = \sin^{-1} \frac{r}{R}$.

The indentation test in general measures the resistance exerted by a material against penetration by the indenting tool and assuming the validity of the adhesion correction, it is considered that the corrected contact pressure is a more accurate measure of the resistance of the material than has hitherto been obtained. Considering first the cone tests, it can be seen that for any given cone and material, and constant initial surface conditions in regard to lubricant, the value of the contact pressure is independent of the load. Variations do occur, but examination shows that they follow no particular sequence, and although variations in the material along the bar cannot be altogether neglected, the author has little hesitation in attributing the main variations in the cone results to small differences in the adhesion conditions occurring in the tests. In all cases the sharper angle cones give higher values, but when allowance is made for the adhesion between the cone and the material, the value of the corrected contact pressure is found to be reasonably constant for the particular material, and independent of the angle of the cone or the applied load. This general result does not apply to manganese steel.

In the case of the ball tests the contact pressures (normal ball hardness numbers using projected areas) show the familiar increases in load, the rate of increase being greatest for manganese steel and least for the work-hardened steel B.E.P. Considering the corrected contact pressures, and excepting manganese steel, it can be seen that for a particular material the value is approximately constant over a certain range of load, which range is dependent on the size of the ball and the material under test. Further, the constant value over this range of load is in fair agreement with the corrected contact pressure given by the cone tests on the same material. For convenient reference the mean values of the corrected contact pressures on the various materials are collected in Table XVII and the standard Brinell hardness numbers are also given.

TABLE XVII.—SUMMARY OF RESULTS.

Material.	Value of μ.	Corrected Contact Pressure in kg. per mm². 45 deg. Cone.	60 deg. Cone.	90 deg. Cone.	120 deg. Cone.	5 mm. Ball.	10 mm. Ball.	Brinell Hardness Number 3,000 kg. 10 mm. Ball.
Annealed Copper ..	0·425	45·3	44·5	46·2	45·6	400–800 45·5	1,250–2,500 44·6	—
Rolled Copper Bar ..	0·35	68	—	70	—	100–1,250 69	300–7,000 68	68
Mild Steel	0·325	110	110	109	107	750–2,000 106	3,000–7,000 105	108
0·48 per cent. C. Steel A	0·28	182	184	182	184	1,000–3,000 180	3,000–10,000 180	183
0·48 per cent. C. Steel B	0·20	—	—	179	182	1,000–3,000 181	3,000–10,000 181	
Annealed Tool Steel ..	0·25	272	277	271	272	750–4,000 280	3,000–10,000 272	274
Manganese Steel	0·30 ?	280	306	276	245	6,000 289	20,000 280	220
Steel B.E.P. Normalised	0·30	—	177	172	173	750–3,000 176	3,000–5,500 173	176
Steel B.E.P. Cold-Worked	0·25	—	214	216	—	250–3,000 212	1,000–5,500 210	218

With the exception of 0·48 per cent. C. Steel B, in which Aquadag was used, the lubricant was vaseline. The figures given above a ball test result are the values of the load over which a mean value of the corrected contact pressure has been taken.

Table XVII brings out a very useful result. The corrected contact pressures obtained in several different ways and expressed as a pressure in kilogrammes per square millimetre, agree fairly well with the standard Brinell hardness numbers for all the materials except manganese steel. The reason for this is fairly obvious; the use of the spherical area in the standard test make a difference in the value of the contact pressure which is of the same order as the adhesion correction, and hence the standard Brinell numbers are approximately the same as the corrected ball and cone contact pressures. The existence of an approximately constant value of the corrected contact pressure over a particular range of load is of considerable interest. It will be noted that the range of load varies for different materials, commencing at low loads on the rolled copper and work-hardened steel, and at about 3,000 kg. to 4,000 kg. load on the remaining materials (except manganese steel) for the 10 mm. ball tests. For the 5 mm. ball tests the loads are proportionately lower. It is usually considered that the increase in ball hardness numbers at the higher loads is due to increased resistance to penetration following on the cold working of the material during a test. The present results show this only occurs up to a certain value of the load, which is dependent on the material; beyond that load further cold working is not apparent, and the resistance remains approximately constant. There is a tendency for the corrected contact pressures to fall at very high loads in the ball tests, but it can hardly be expected that the adhesion correction is valid when a portion of the surface of the ball is nearly parallel to the line of action of the applied load; a condition which occurs when the ball is deeply embedded in the material. In the case of manganese steel, no value of μ could be found which gave agreement of the various cone test results. No direct evidence was obtained on which to base a value of μ, but it was considered that $\mu = 0{\cdot}3$ would show the general trend of the results. It is inferred from the corrected results on this material that continued cold working has occurred at all loads, and

* Presented at a meeting of the Institution of Mechanical Engineers on Friday, April 24, 1925. Abridged.

† Proceedings I.Mech.E., 1918, page 485.

it is very doubtful if the maximum value of the corrected contact pressure can be obtained in a ball test. The cone test results, showing increased contact pressures with decrease in the vertical angle of the cone, also support this inference, which is consistent with the known properties of the material.

In general, from the results of the present investigation it appears that the resistance to indentation of a material by a ball or cone, when corrected for adhesion between the material and the ball or cone, is reasonably independent of the applied load and the indenting tool, provided the vertical angle of the indenting cone is not greater than a certain limiting value, and the ratio of the ball diameter to the impression diameter is not greater than a corresponding limiting value. The limiting values specified above are dependent on the test material, and are apparently related in some way to the degree of work hardening which has been given or can be given to the material. The approximate maximum limiting values for the ball ratio are given in Table XVIII, and have been taken from the various results given in the present Report. It seems likely that the ratio should be independent of the ball diameter for a given material. For the materials considered, excepting manganese steel, the 120-deg. cone appears to be less than the maximum limiting cone angle.

The definition has been made in general terms, but it will be seen from Table XVIII that the limits are fairly wide. Thus, excepting manganese steel, the 90-deg. and 120-deg. cones are within the cone limits on all the materials, and also the standard loads on the 10-mm. and 5-mm. balls. It is considered that all tests made within the limits of the definition

TABLE XVIII.—*Approximate Maximum Limiting Ball Ratios from Present Results.*

Material.	Diam. of Ball. / Diam. of Indentation. 10 mm. Ball.	Corresponding Minimum Load.	Diam. of Ball. / Diam. of Indentation. 5 mm. Ball.	Corresponding Minimum Load.
		Kg.		Kg.
Annealed Copper ..	1·8	1,250	1·6	400
Rolled Copper Bar ..	4·2	300	3·8	100
Mild Steel	1·8	3,000	1·8	750
0·48 per cent. C. Steel ..	2·3	3,000	2·0	1,000
Annealed Tool—Steel ..	2·7	3,000	2·7	750
Manganese Steel	less than 1·2	—	less than 1·2	—
Steel B.E.P., Normalised ..	2·2	3,000	2·2	750
Steel B.E.P., Cold-Worked	4·1	1,000	4·1	250

are directly comparable, and appear to be a measure of the same property of a material in all cases. It is the opinion of the Author that the standard Brinell test is just within the limits of the definition for the majority of engineering materials within the Brinell range 70 to 300, but it is probable that exceptions, in addition to manganese steel, may be found; annealed nickel seems a possible case. At the higher hardnesses (say, 300 Brinell number and upwards), further experimental work is necessary before any definite conclusions can be drawn.

Dr. Unwin has given a definition of hardness as "the intensity of pressure at which the material yields or flows in the conditions of the indentation test" (ENGINEERING, May 17 and June 21, 1918), but probably because of the differences obtained with various indenting tools and variations with load in ball tests, his definition does not appear to have been generally accepted. The corrected contact pressures given in the results represent a more rational value of the intensity of pressure than the usual ball and cone hardness numbers, and it has been shown that the value, within certain limits, is independent of the method of test. The hardness, expressed in this way, can therefore be regarded with greater certainty than has hitherto been the case, as a definite property of a material. During the last few years a large amount of experimental work on indentation hardness has been carried out, and attempts have been made to give a real meaning to the term "hardness." It is considered that the present results substantiate Dr. Unwin's definition of indentation hardness as a definite property of a material when the time effect during a test can be neglected. In static indentation tests on the harder materials the time effect is small when the load is applied for 30 seconds, but for soft materials, and for all materials under impact conditions, presumably the rate of yield or flow, and the intensity of pressure would not be independent. It seems probable that allowance for adhesion between the indenting tool and the material in impact indentation tests would yield interesting and possibly valuable results. Whether the distribution of the corrected pressure over the indentation can be determined, and the result correlated with the other mechanical properties of a material, remains to be shown, but in the opinion of the Author it is not at all impossible.

Direct conversion of cone test result to ball test result requires a knowledge of the value of μ, but it appears that a value of $\mu = 0{\cdot}3$ might reasonably be assumed over the Brinell range of 70 to 300, without causing any very serious errors. The rule

$$\text{Brinell hardness number} = \frac{\text{Cone hardness } \left(\frac{P}{\pi r^2}\right)}{1 + \mu \cot \theta} = \frac{\text{Cone hardness}}{1{\cdot}3},$$

would then give agreement of ball and 90-deg. cone test results.

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*Some Practical Aspects of the Scratch Test for Hardness.**

By GEOFFREY A. SHIRES, M.Sc., A.I.C.

ONE of the primary objects undertaken was the construction of a sclerometer sufficiently trustworthy in action to allow of its being employed for accurate measurement in the subsequent part of the investigation, and at the same time of a design and mode of operation simple enough to serve as a model for an instrument for practical use.

The apparatus consisted of two parts, the diamond holder and the support. The diamond holder consisted of a brass tube (approximately 1 mm. in wall thickness). A plug was sweated into the bottom end of this tube, and contained a threaded hole into which any desired diamond mount could be fitted. The diamond was mounted in a piece of cartridge-shaped gilding metal, threaded at the top end so as to screw into the plug. The support was a brass tube with somewhat thicker walls (approximately 3 mm.), the lower end of which was flanged to enable the tube to stand upright more readily, and to carry the bearings. These consisted of three small steel balls held in position by a thin perforated disc screwed on to the bottom of the flange. It was found that if the balls were allowed to remain loose and free to run on the work, a slight degree of "stagger" was experienced; the disc was therefore screwed up tightly so that the function of the balls was really to provide a three-point contact rather than a true bearing. The diamond holder was lubricated with graphite, and was a sliding fit in its support. To prevent rotation, a vertical slot was cut in the holder, and engaged with a pin screwed through the wall of the support. The diamond and its holder were of known weight (50 grammes), and additional lead weights of 50 grammes each were made to fit into the inside of the tube.

The method of operation was very simple. To make a scratch on a large surface, the sclerometer was placed upright upon the material, and slowly drawn along it by hand. The diamond was screwed into the holder in such a way that the correct direction for drawing the instrument was indicated by the projecting pin in the support. If a long scratch was required, use was made of a straight edge as guide. Small samples were prepared for scratching by some form of mounting. The sclerometer described was used throughout the present work and found very satisfactory. Circumstances have prevented further evolution in the design of the instrument by the present writer, but a suggestion is offered as to the desirability of replacing the dead weights by an adjustable spring in compression, thus allowing the easy application of any load within specified limits, and enabling the instrument to be used in any position.

The microscope used was fitted with a cobweb micrometer eye-piece, by Beck, having two cross wires, one fixed and one capable of movement across the field of vision by an external graduated screw. The screw head was divided into 100 divisions, and the objective and tube length were so chosen that one complete revolution of the screw produced a movement of the cross wire of 0·02 mm., while one-twentieth of a revolution, or five small divisions, corresponded to a movement of 0·001 mm. or μ. It was found feasible to estimate further to 0·5 μ; beyond this the error in observation outweighed the sensitivity of the apparatus. In this way measurements were made of the widths of scratches on harder materials up to Brinell 650.

Table I shows very clearly the limitations of the scratch test, illustrating the small differences noticeable in the scratch widths for a comparatively great difference in hardness, the whole range of 450 Brinell numbers only corresponding to a scratch width variation of 0·01 mm.; moreover, above about 300, ranges of considerably more than 10 Brinell numbers are embraced by 0·5 μ, the limit of sensitivity of measurement available. With the Beck cobweb eye-piece described above, the sensitivity was at the most 0·3 μ, and more probably 0·5 μ, and it will be seen that the method cannot be extended with accuracy for materials of Brinell hardness beyond about 300. The introduction into works' practice of a sclerometer of the nature of a workman's tool, with a complementary measuring outfit of a high degree of scientific precision and complexity, verges upon the absurd.

TABLE I.—*Relation between Scratch Widths and Brinell Hardness Numbers for Harder Material. (Steels.)*

Load on Diamond = 50 grammes.

Width of Scratch in μ.	Brinell Hardness.
29	203
28	230
27··	240
24·5	320
24	346
23·5	363
22	430
21·5	453
21	494
20·5	517
20	585
19·5	620
19·5	631
19	653

While the use of a curve for the expression of Brinell hardness from an observed scratch width was found to give quite satisfactory results, the drawback of the necessity of constructing a curve for each diamond and load used suggests the desirability of an alternative method when only occasional scratch hardness measurements are required, and it is desired to use any available diamond without previous calibration. The admirable work of Hankins will not be dealt with in detail here; it will suffice to mention that this investigator suggested a scale of scratch hardness values K, capable of serving as an independent scale for the measurement of scratch hardness, and at the same time readily referable to Brinell hardness numbers. From experiments upon the relation between the width of scratch and the load on the diamond, a straight line law was shown to exist between these two quantities, and lines illustrating this relation for various materials all intersect at the same point. The co-ordinates of this point were taken as p and q, and the law was then expressed as $(P - p) = K(w^2 - q)$, where P = load on diamond, w = width of scratch, K = material constant. Then $K = \frac{P - p}{w^2 - q}$, and will have the dimensions of s stress, and was taken by Hankins as a convenient measure for scratch hardness determination. This resumé of the derivation of Hankins' scratch hardness number K has been given in order to indicate the nature of the scale suggested by him, in which K was calculated in kilogrammes per square millimetre for a number of materials. It will be plain that, such a scale being granted, tables and curves in the nature of calibrations may again be drawn up. The scratch hardness number K is a definite and independent quantity, without reference to Brinell hardness, and provides a definite unit for establishing a scratch hardness scale.

There are many instances in which the Brinell indentation tests are impossible owing to the nature of the work to be tested. The impression left by the ball may conceivably be an undesirable feature upon certain articles tested before being sent out after manufacture. Again, frequently hardness tests are required on objects too small to take a Brinell impression or too thin to give a valid Brinell figure. It can be safely said that a suitable scratch can always be readily made upon such an article with a convenient type of sclerometer and a suitable load on the diamond. Local variations in hardness, too, can be readily distinguished by the sclerometer. Moreover, it is conceivable that, in the extreme case of a divergence in hardness over a very small portion of material, a Brinell impression might cover the whole of the area concerned. A scratch can record the hardness from point to point. Further, a scratch of considerable length forms a very clear means of illustrating a progressive change in hardness over a particular region. A further example of the use of the scratch test in bringing out local hardness differences is in the recording of the hardness of the constituent crystals in an alloy. This has been well described by Bierbaum in a paper upon the study of bearing metals. Crystal hardness in alloys such as brasses, bronzes, and white metals can be clearly distinguished by the measurement of extensive scratches, and much information as to the nature and identification of such crystals should be ascertainable by the scratch method.

In addition to instances in which the Brinell test is impossible, owing to mechanical circumstances peculiar to the work in question, there are at the same time cases where the scratch test is superior to the ball or other tests by virtue of its physically distinct nature. The fact that the scratch test sometimes facilitates the detection of hardness differences not apparent by the indentation method, as with the sprayed coatings, and with "superhard" materials, suggests that a slightly different property or combination of properties is being measured.

* Paper read before the Institution of Mechanical Engineers on Friday, April 24, 1925. Abridged.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.*

By M. EUGENE BRILLIÉ.

(*Continued from page 527.*)

SOME of the automotor vehicles which have been mentioned comprise special mechanical appliances devised for reasons which may now be considered. The conditions for starting a rail motor are not the same as those which apply in the case of the automobile. If it is desired to use the whole power of the motor, it must be remembered that the rail motor gives facility for hauling a train having a tonnage eight to ten times as great, for equal power and speed, as could be hauled on the road; this is due to the difference between the resistance to traction on rails and on the road (9 to 13·5 lb. per ton, in place of 45 to 70 lb. per ton), and, moreover, the gradients are generally much less severe.

The problem of starting, taking into consideration the increased inertia to be overcome, is presented in a quite different form in the case of the railway, and requires a clutch having much greater surface, so as to enable it to withstand slipping for long periods without damage. As an example, one may compare the slipping of the clutch under two different cases of starting on the level; in these, slipping is taken into account from the instant at which starting commences until slipping ceases, at a speed which we will assume to be one-half of the normal speed.

(1) A Paris motor omnibus with 30 h.p. motor; weight loaded, 8 tons; 1st speed, 4·4 miles per hour; 2nd speed, 8·8 miles per hour; 1st speed: period of slipping, 1 second; 2nd speed, 3 seconds.

(2) Rail motor of the French State Railway with 60 to 80 h.p. motor; weight, 14 tons; 1st speed, 8·8 miles per hour. Rail motor alone has a period of slipping at starting of 4 seconds; with a 10-ton trailer, of 7 seconds; with a 50-ton trailer, of 15 seconds; and with a 100-ton trailer, of 25 seconds.*

It is therefore necessary, in order to obtain such starting efforts, to provide very large friction surfaces; but even though this be done, the question of changing speed has still to be considered. The driven portion of the clutch, which is connected to the first train of gear change wheels, has itself considerable inertia, which makes it difficult to change from one speed to another. This operation, which, even in the ordinary motor-car, requires a certain knack for changing without noise, requires in the case of such large clutches an amount of manual dexterity that is inconsistent with ordinary railway practice. In the case of such powerful motors, it has consequently become necessary to adopt special devices, which we shall now investigate.

The Fieux clutch, which is fitted to the Schneider rail motor vehicles, consists of a combination of two separate elements, consisting of clutches of different gripping effect. The two separate elements can be seen mounted on the lower shaft in the general view of the clutch and gear given in Fig. 49. The one element which will be called the slipping clutch, and which is shown to the left, has very large bearing surfaces. Friction is developed between the internal surface of a cylindrical drum permanently attached to the driven shaft and a metal spiral, driven by the motor; this spiral is subjected to the differential action of (*a*) centrifugal masses which tend to make it grip, and of (*b*) the driving couple of the engine, which has the opposite effect; the clutch is oil-filled and automatic. During the time it is starting the vehicle, it transmits the driving couple of the engine by slipping; the speed of the engine becomes regular as the result of the mechanical arrangement of the clutch, and is independent of the coefficient of friction, which may vary and have a low value compared with the maximum driving couple of the engine. When the speed of the vehicle has become such that it corresponds to the speed of the engine, locking takes place and the motor can then be accelerated up to its normal speed. The other element, known as the coupler, is a clutch capable of transmitting a large effort, and has surfaces subjected to high pressures; the driven portion of the coupler has only very small inertia; it is not required to be capable of a large amount of slipping, and is actuated in the manner of the ordinary friction clutch.

This arrangement of two elements, the slipping clutch and the coupler, works in the following manner. The small inertia of the coupler enables the operations of changing speed to be made easily and independently of manual skill. All the slipping takes place automatically in the slipping clutch. The driving couple supplied by this is a function of the speed of the engine, and if the speed should drop owing to the resistance of the train, for example, or through error in gear selection, it

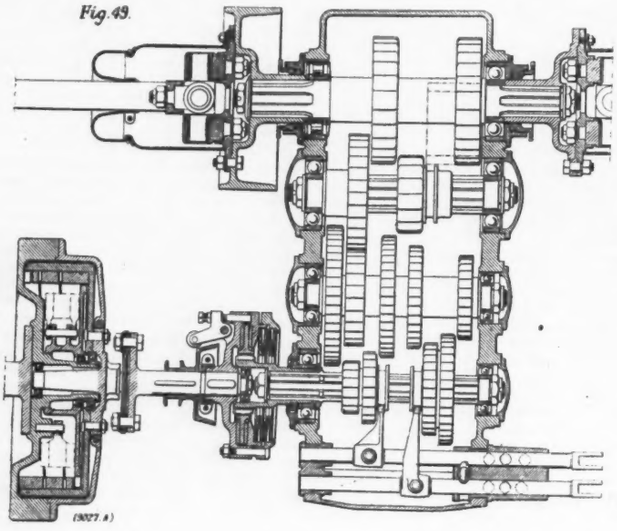


Fig. 49.

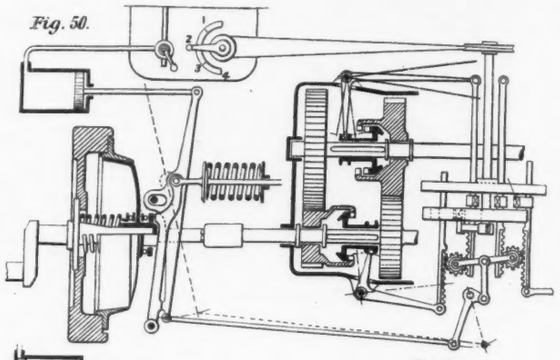


Fig. 50.

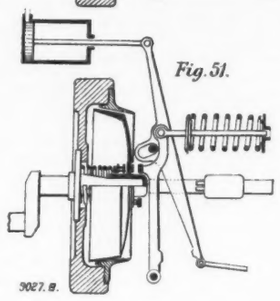


Fig. 51.

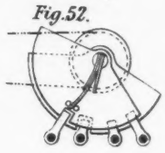


Fig. 52.

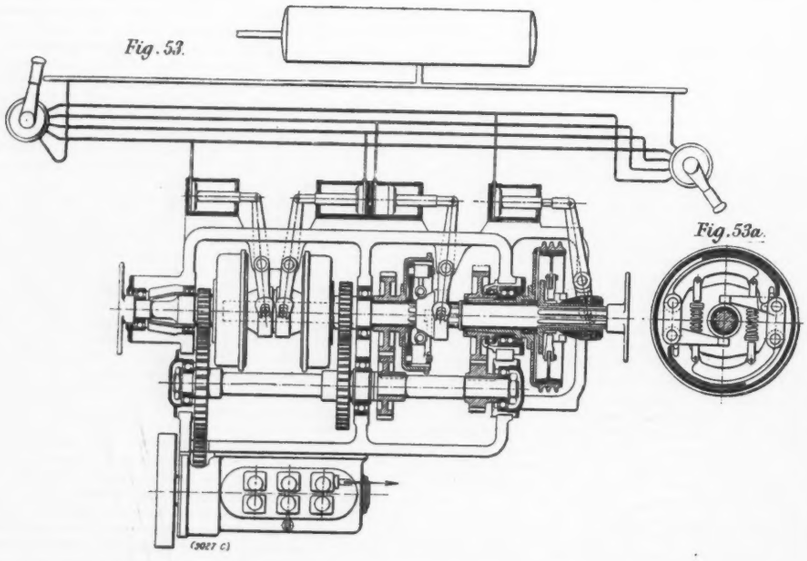


Fig. 53.

Fig. 53a.

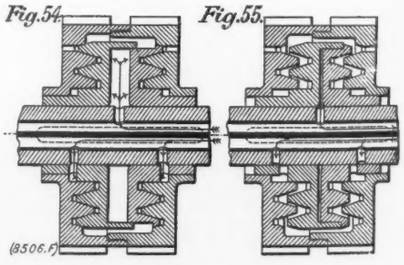


Fig. 54. Fig. 55.

* **Paper read** before the British Section of the Société des Ingénieurs Civils de France on April 1, 1925. Abridged.

* This vehicle is used for shunting operations, hauling 100 tons on an up-grade.

uncouples automatically, so that the engine is not stopped.

The slipping clutch is designed to allow of slipping for several minutes at full load. The heat evolved is transferred to the oil and radiated by the casing of the rotating element. The Fieux apparatus has the advantage that it can be adapted to the ordinary sliding gear or dog clutch arrangements, which are the most simple and satisfactory appliances in general use, and it can be applied to motors of 200 h.p. and upwards.

When changing gear on a rail car and the engine has been declutched, if it were possible to bring the speed of the first train of gears and that of the freed element of the clutch into synchronism with the new speed that is to be engaged, the entry of the dogs (or of the gear teeth) would be effected without difficulty, whatever might be the inertia of the driving element of the clutch. The Mylius gear fitted to the Hawa rail-motor vehicles presents a solution of this problem. An arrangement of this gear is shown diagrammatically in Figs. 50 to 52.

Fig. 56.

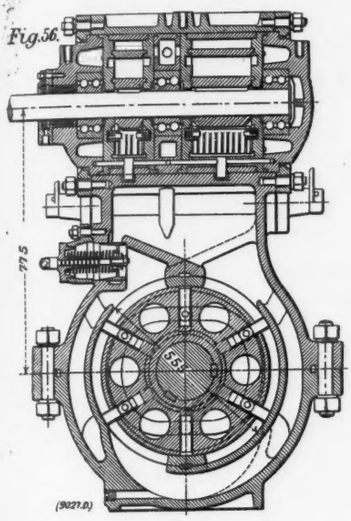


Fig. 57.

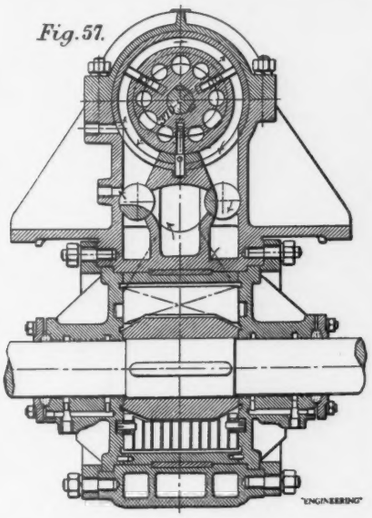
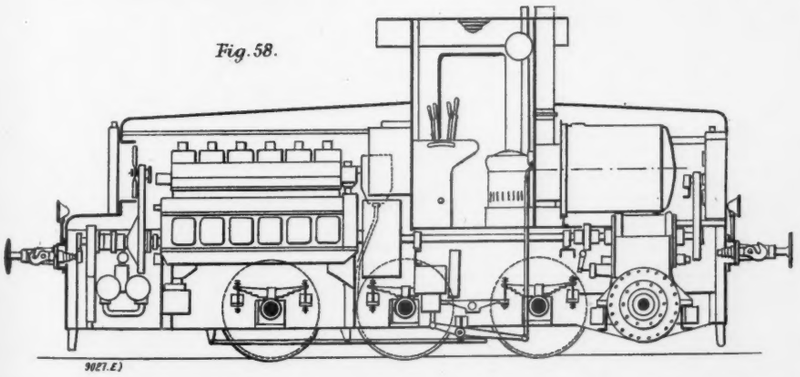


Fig. 58.



In order to change speed, the mechanism must perform two movements: the first is preparatory, and operates a selector by setting the change-gear handle A in the notch that corresponds to the speed to be engaged. The selector T takes up a position which allows the levers corresponding to this speed to be actuated while the others remain locked. In the gear as shown in Fig. 50, the first speed is in gear and the second speed has been selected; the corresponding notch of the selector disc T enables the locking piece m_2 to move while the locking disc U, to which force is applied by the spring t, is still held in position by the locking piece m_1 of the first speed. The second operation is that of engagement; it is effected by the air-cock B, which controls the piston C, driven by compressed air, which, acting on the rocking lever H, acts simultaneously on the clutch and on the change-gear locking bars. The gear operates in two stages.

First stage: the cylinder C is open to exhaust; the pressure of the spring F, which is stronger than the spring E, releases the clutch, as shown in Fig. 51; at the same time the rocking lever H moves over and acts through a bell-crank h on a balance gear L, 1, 1′ which tends to lift the locking bars of the four speeds, but can only move those that are not locked, that is to say: (1) The bar M_1, which withdraws the sleeve P_1 of the first speed to its dead point, and of which the locking bar m_1 will be locked by the rotation of the disc U under the action of the spring t. (2) The bar M_2 of the second speed, which will engage the friction cone of the sleeve P_2 with the cone of the wheel R_2. The latter, being driven by the auxiliary shaft K, will cause the primary gear train Q_2, J, D to run at a speed that synchronises with that of the auxiliary shaft K, that is to say, with the speed of the vehicle. Second stage: the air is allowed to enter the cylinder C; the lever H rocks in the opposite direction; under the action of the balanced gear L, 1, 1′ the sleeve P_2 leaves the friction cone and moves so that its dogs engage with those of the wheel R_2; the engagement of the second speed is thus completed and is immediately followed by the engagement of the clutch (Fig. 50). Gear changing can consequently be effected without shock and by a very simple manipulative operation. The method can be applied to an automobile having two driving compartments and two motors.

A third method consists in arranging the gears so that they are always in mesh, and providing a clutch for each speed. This method has been mentioned in connection with shunting locomotives having two speeds only. The A.E.G. rail motor vehicles are fitted with an arrangement, shown in Fig. 53, having four speeds; each clutch T_1, T_2, T_3, T_4, is operated respectively by pistons controlled by air pressure K_1, K_2, K_3, K_4. The clutches for the second, third and fourth speeds are enclosed in the gear-box; the clutch for the first speed T_1 is external. It is constructed of larger dimensions because it comes into play for starting. This method enables two engines to be used for driving, and it also enables two rail-motor vehicles coupled together to be driven from the driver's compartment of either.

The Winterthur Locomotive Company has applied the method of multiple clutches, with hydraulic control gear for the elements. Oil under pressure is used to force together the grooved clutch plates, which form the clutching elements, with those made in one with the gears. The oil is supplied through holes drilled in the shafts (Figs. 54 and 55). The apparatus is in use on a shunting locomotive fitted with a 100-h.p. Diesel motor, weighing 16 tons, and having four speeds of 4, 9, 15, and 20 km. per hour (2·5, 5·5, 10·5, and 12·5 m.p.h.).*

Other manufacturers use electro-magnetic clutches. The Daimler Company of Coventry constructed a rail-motor vehicle in 1913 having a clutch of this type. The novel arrangement of the motor sets at the sides under the body-work, driving on to the ends of the driving axles, was a special feature. The Gomsa Works (Vereinigte Staatliche Maschinenfabrik) are at present building a locomotive, for the Russian Government, having a Diesel-Krupp motor of 1,100 h.p., reversible, and driving through gearing. There are three speeds, and an electro-magnetic clutch of the Eisenach make. This locomotive will have five coupled axles, a bogie, and a Bissel bogie; it is expected to weigh 125 tons.

Mechanical methods of transmission, which have justified their existence by nearly thirty years' successful use in automobile practice, can be perfectly well adapted to the requirements of traction on rails; they have the advantage of giving a high efficiency for small weight, and the special problems involved in their use have been solved in various ways.

Mixed Transmission Gears.—Under this heading are comprised mixed systems in which mechanical transmission is used in combination with auxiliary arrangements (electrical, pneumatic, or others) brought into play for starting and under exceptional circumstances. For instance, the Pieper electro-mechanical rail motor vehicle is driven by a motor-dynamo set which drives both axles through cardan shafts with magnetic clutches for starting. During starting, and on heavy work, the dynamo receives current from a battery, and assists the motor; on the other hand, on easy sections of the route, the excess energy delivered by the motor is used for charging the battery. Under normal conditions, the vehicle runs on direct drive.

In the Thomas electro-mechanical transmission,† the energy supplied by the motor is distributed by an epicyclic gear through two simple transmission gears: the one a direct drive to one of the axles, the other consisting of a means of transforming energy by the use of a generator driven through the epicyclic gear supplying current to a motor that drives another axle. At starting and on heavy work, the greater portion of the energy is transformed so as to increase the torque; in normal running, the transmission is direct. In the Hautier pneumatic-mechanical transmission the principle is similar to that of the electro-mechanical gears, but the transformation of energy is effected by the use of compressed air. In ordinary running, the epicyclic gear works as a speed reduction gear. An experimental locomotive was built in 1913 by Schneider, and proved to have a good efficiency when tested with the dynamometer.‡

Hydraulic Transmission Gears.—Transmission from the engine to the wheels may be effected by hydraulic gear working as a transformer of energy and enabling any desired speed ratio to be obtained for different running speeds of the vehicle. The liquid used is oil. The installation in general comprises a compressor or pump of variable delivery driven by the engine, and an oil engine (hydraulic engine) driving the wheels, the two appliances being connected by a double system of piping. The installation should include a by-pass arrangement in order to avoid the hydraulic engine driving backwards through the motor engine when being driven by the wheels, or when the vehicle is running with the motor engine stopped.

Of these gears the Lentz transmission has been longest in use on railways and has been adopted by several German firms for shunting engines of from 75 to 400 h.p.

The pump and the hydraulic engine are both of the rotary type with sliding vanes. The pump is so constructed that several chambers, or their equivalent, can be used independently or in parallel. The Lentz gear shown in Figs. 56 and 57 differs in form from the cylinder type illustrated recently in ENGINEERING.§ In this gear made for the Badische Lokomotivwerke, who are designing more powerful locomotives (Fig. 58) the pump and hydraulic engine have a common body.

The Motor-Lokomotiv-Verkauf-Gesellschaft of Karlsruhe, exhibited a locomotive at Seddin fitted with the Lentz gear and having a Baden motor of 160 h.p. It is illustrated in Figs. 59 and 60. In this case the pump and hydraulic engine are separate and the speeds are changed by putting one, two or three chambers into circuit. The reversing cock, shown in mid-position, is arranged above the hydraulic engine. When the cock is in this position the pipes are put

* See ENGINEERING, November 21, 1924. Vol. cxviii, page 701.

† See ENGINEERING, May 5, 1911 (vol. xci, page 594), and June 25, 1915 (vol. xcix, page 696).

‡ This locomotive was described by the author in the Proceedings of the Société des Ingénieurs de France, April, 1913.

§ See page 350, *ante*.

TRACTION ON RAILS BY INTERNAL-COMBUSTION ENGINES.

Fig. 59.

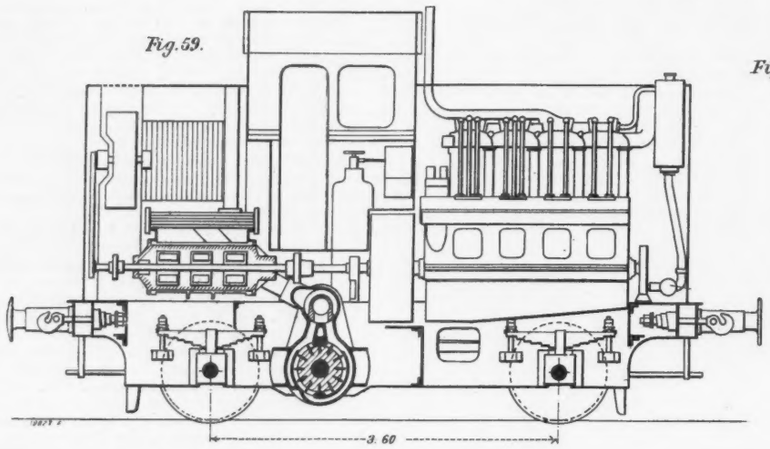
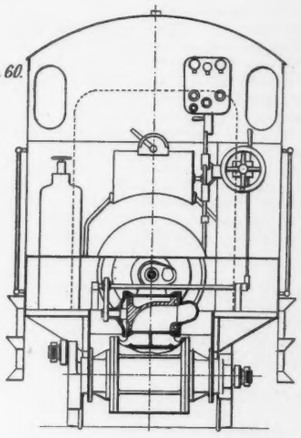


Fig. 60.



into communication with each other and form a by-pass between the hydraulic engine chambers.

In other transmission systems, the transmitter enables an infinitely variable range of speed from zero to a maximum, and also reversing, to be obtained by the use of a variable-stroke gear, operated by eccentric, controlling the pump strokes. Amongst these appliances may be mentioned the Hele-Shaw, Janney, Naëder, Schwartzkopff-Huwiler, &c. In the Hele-Shaw system the pump consists of six cylinders arranged in star form as shown in Figs. 61 and 62, turning about a centre that carries the inlet and exhaust ports. The stroke is controlled by a circular ring of variable eccentricity by means of the operating lever. When this lever is in its middle position, the stroke is reduced to zero; the extreme position corresponds respectively to the maximum of delivery in one direction or the other. The driven mechanism consists of a similar appliance but of fixed eccentricity. Figs. 63 and 64 show this system applied to a shunting locomotive built by the Société Française de Transmission; several of these locomotives are at work on the French Northern Railway. Small rail motor vehicles of the M.E.P. type (McEwan, Pratt and Co.) have been constructed using the transmission gear.

Vickers Limited, have constructed an experimental locomotive in which a 75 h.p. semi-Diesel engine is direct coupled to an hydraulic pump. The hydraulic motor is arranged at right angles to the pump, the pipe connection affording a solution for the width and length problem that usually forms a serious difficulty in arrangements of the kind. The hydraulic motor is carried on a shaft which drives both axles by chains. In a later design, the wheels are driven by coupling rods from the motor shaft.

The Schwartzkopff-Huwiler transmission was fitted to a locomotive of 200 h.p. exhibited at Seddin by the Berliner Maschinenbau A.G., and shown in Fig. 65. In this system, the compressor and transmitter are of the blade type with an arrangement that enables the volume swept out by the blades to be varied in both the driving and driven appliances. In the driving element, the variation in output from zero to the maximum is controlled by the engine driver. In the driven element increase in the operating surfaces of the blade comes into effect automatically when the oil pressure reaches a certain amount; this is accompanied by a corresponding increase in the tractive effort. The whole of the gear is operated by hydraulic means. The engine has six cylinders and runs at 440 r.p.m.; the radiator is arranged in the roof with forced draught from a blower provided at the end of the vehicle. The locomotive weighs 30 tons.

In hydraulic transmission gears it is possible to use the driving element of one system in conjunction with a driven element of another system. In some examples the Janney driving element is used with a Lentz driven element. The Janney driving element has the cylinders arranged parallel to the shaft, and rotating in the manner of a revolver barrel*; the stroke is varied by the inclination of a swash plate, which in its most oblique position gives maximum volume. When the disc is at right angles to the shaft, the delivery is nil; when the inclination is in the opposite direction the direction of flow is reversed. In order to prevent longitudinal forces acting on the shaft two sets of pumps are used. The mixed arrangement of Janney driving and Lentz driven elements was adopted in the design of a 1,200 h.p. locomotive, designed by Mr. Meineke, engineer for the Russian Railways, but the scheme was not carried out, for the reason that it was considered preferable to adopt gearing and electro-magnetic clutches.

* The arrangement is similar to that of the West steam engine of about 1875.

Fig. 61.

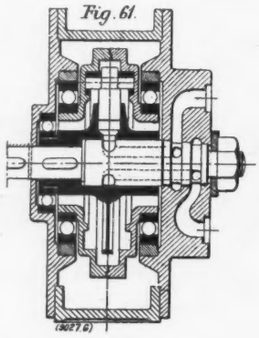


Fig. 62.

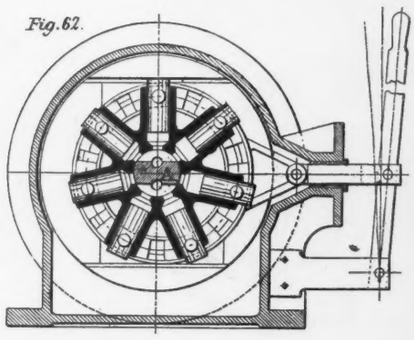


Fig. 63.

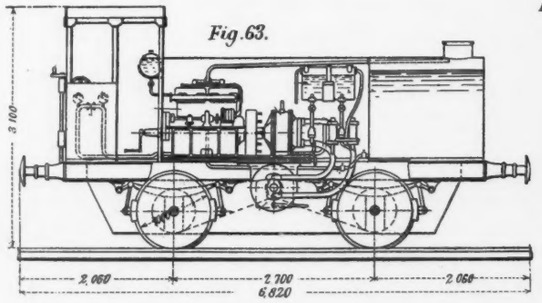


Fig. 64.

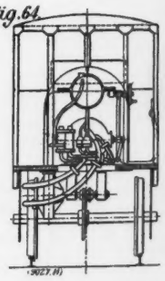
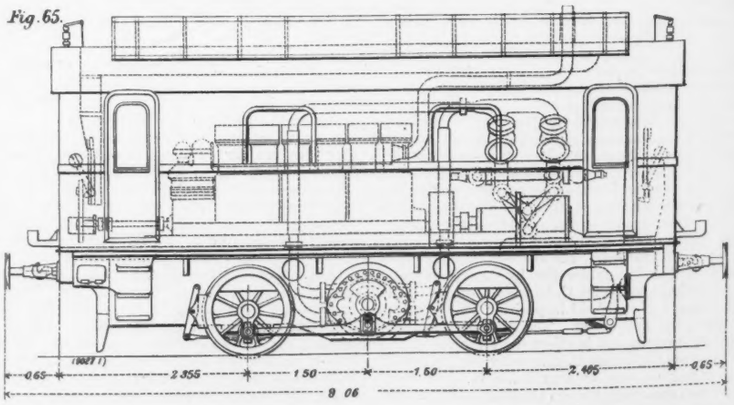


Fig. 65.



Hydraulic transmission is extremely simple to handle. Its mechanical efficiency may attain 75 per cent. Of eight normal-gauge shunting locomotives exhibited at Seddin, seven were fitted with hydraulic transmission.

(To be continued.)